

Attendees of the 28<sup>th</sup> Annual Meeting of the  
Orthopaedic Trauma Association,

Welcome to Minneapolis, the City of Lakes. This city's conference center makes a perfect venue for the diverse set of educational activities that will transpire over the coming days. As a bonus, this premier Academic experience takes place with a backdrop of spectacular urban lakes and a park system that uniquely integrates this preeminent business and cultural center with the natural beauty of the region.



*Robert A. Probe, MD*

Over the preceding twenty-seven years, the character of OTA's Annual Meeting has gone through some dramatic change. In the early years, participants were a limited number of Senior Traumatologist sharing experiences from the podium. As the specialty has expanded and evolved, so has the diversity in training, background and experience of those attending this meeting. Responding to the spectrum of educational need, Jim Goulet and the Program Committee have introduced substantial educational innovation to this year's program. Recognizing that Trauma patients are increasingly becoming cared for by teams, this year we have specific offerings for nurses and advanced practice providers. Additionally, we have specific offerings for basic scientist, residents, young practitioners, researchers and the general orthopaedist interested in trauma.

Layered into this segmented educational approach we have a combination of symposia, didactic sessions, surgical skills teaching, small group discussions and presentations of original research. With regard to the latter, the Program Committee has selected one-hundred podium presentations and two-hundred posters to be presented from a record number of submissions. With so much being offered we are confident that everyone can create a customized schedule that enhances your ability to contribute to the care of the trauma patient.

Given the rich history that Minneapolis brings to Orthopaedic Trauma, I can't imagine a more appropriate place for this year's Annual Meeting. I hope this will prove to be both an educational and social success for you.

Warm regards,

A handwritten signature in cursive script that reads "Robert Probe".

Robert Probe, MD  
President, Orthopaedic Trauma Association



**OTA Membership Directory available at [www.ota.org](http://www.ota.org).**  
Search by name or location. Directory updated weekly.  
Email addresses available via the 'Members Only' page.

Attendance at the OTA Annual Meeting authorizes the OTA to capture your image or likeness in photographic, digital video, or other electronic format, and authorizes the OTA to use said image or likeness in marketing materials to promote OTA, including print, electronic and on the internet. OTA warrants that its use of the image or likeness will not be in a negative manner. OTA has no control over the use of the image or likeness by third parties and therefore makes no express or implied warranties on any use by third parties.

## **Orthopaedic Trauma Association**

6300 N. River Road, Suite 727  
Rosemont, IL 60018-4226, USA  
Phone: (847)698-1631  
Fax: (847)823-0536  
e-mail: [ota@aaos.org](mailto:ota@aaos.org)  
Home Page: <http://www.ota.org>

### **OTA Staff**

Kathleen A. Caswell, *Executive Director*  
Sharon M. Moore, *Society Manager*  
Diane Vetrovec, *Manager, Education and Research*  
Paul M. Hiller, *Society Coordinator*  
Darlene A. Meyer, *Society Coordinator*  
Alivia Payton, *Education and Research Program Administrator*

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<b>SCIENTIFIC POSTERS</b>	<i>Convention Center, Hall C</i>
Open: Thursday	2:30 pm - 5:00 pm
Friday	7:00 am - 5:00 pm
Saturday	7:00 am - 1:30 pm
<b>TECHNICAL EXHIBITS</b>	<i>Convention Center, Hall C</i>
Open: Thursday	2:30 pm - 5:00 pm
Friday	9:00 am - 5:00 pm
Saturday	9:00 am - 1:30 pm
<b>SPEAKER READY ROOMS</b>	
Basic Science Focus Forum: <i>Convention Center 101 AB</i>	
Annual Meeting: <i>Convention Center 202 AB</i>	
Open 6:30 daily — Wednesday thru Saturday.	

**NOTE: Cameras (including digital and video cameras)  
may NOT be used in any portion of the meeting.**



## ORTHOPAEDIC TRAUMA ASSOCIATION HISTORY

### PAST PRESIDENTS

Ramon B. Gustilo, MD, Founding President		Andrew R. Burgess, MD	1999-00
Michael W. Chapman, MD	1985-87	M. Bradford Henley, MD, MBA	2000-01
Charles C. Edwards, MD	1987-88	Donald A. Wiss, MD	2001-02
John A. Cardea, MD	1988-89	Thomas A. Russell, MD	2002-03
Bruce D. Browner, MD	1989-90	Marc F. Swiontkowski, MD	2003-04
Joseph Schatzker, MD	1990-91	Roy Sanders, MD	2004-05
Richard F. Kyle, MD	1991-92	Paul Tornetta, III, MD	2005-06
Robert A. Winqvist, MD	1992-93	Michael J. Bosse, MD	2006-07
Peter G. Trafton, MD	1993-94	Jeffrey O. Anglen, MD	2007-08
Kenneth D. Johnson, MD	1994-95	J. Tracy Watson, MD	2008-09
Alan M. Levine, MD	1995-96	David C. Templeman, MD	2009-10
Lawrence B. Bone, MD	1996-97	Timothy J. Bray, MD	2010-11
James F. Kellam, MD	1997-98	Andrew N. Pollak, MD	2011-12
David L. Helfet, MD	1998-99		

### ANNUAL MEETINGS

September 14 - 15, 1985	New York, New York, USA
November 20 - 22, 1986	San Francisco, California, USA
November 19 - 21, 1987	Baltimore, Maryland, USA
October 27 - 29, 1988	Dallas, Texas, USA
October 19 - 21, 1989	Philadelphia, Pennsylvania, USA
November 7 - 10, 1990	Toronto, Ontario, Canada
October 31 - November 2, 1991	Seattle, Washington, USA
October 1 - 3, 1992	Minneapolis, Minnesota, USA
September 23 - 25, 1993	New Orleans, Louisiana, USA
September 22 - 24, 1994	Los Angeles, California, USA
September 29 - October 1, 1995	Tampa, Florida, USA
September 27 - 29, 1996	Boston, Massachusetts, USA
October 17 - 19, 1997	Louisville, Kentucky, USA
October 8 - 10, 1998	Vancouver, British Columbia, Canada
October 22 - 24, 1999	Charlotte, North Carolina, USA
October 12 - 14, 2000	San Antonio, Texas, USA
October 18 - 20, 2001	San Diego, California, USA
October 11 - 13, 2002	Toronto, Ontario, Canada
October 9 - 11, 2003	Salt Lake City, Utah, USA
October 8 - 10, 2004	Hollywood, Florida, USA
October 20 - 22, 2005	Ottawa, Ontario, Canada
October 5 - 7, 2006	Phoenix, Arizona, USA
October 18 - 20, 2007	Boston, Massachusetts, USA
October 15 - 18, 2008	Denver, Colorado, USA
October 7 - 10, 2009	San Diego, California, USA
October 13 - 16, 2010	Baltimore, Maryland, USA
October 12 - 15, 2011	San Antonio, Texas, USA

# ORTHOPAEDIC TRAUMA ASSOCIATION ORGANIZATION

## 2012 BOARD OF DIRECTORS

President – Robert A. Probe, MD  
President Elect – Andrew H. Schmidt, MD  
2nd President Elect – Ross K. Leighton, MD  
CFO – David J. Hak, MD  
Secretary – Heather A. Vallier, MD  
Immediate Past President – Timothy J. Bray, MD  
2nd Past President – David C. Templeman, MD  
Member-at-Large – Lisa K. Cannada, MD  
Member-at-Large – Douglas W. Lundy, MD  
Member-at-Large – David C. Teague, MD  
Annual Program – James A. Goulet, MD

### **NOMINATING** (*Elected Committee*)

Andrew N. Pollak (Chair)  
Christopher T. Born  
Michael D. McKee  
Robert V. O'Toole  
Marc F. Swiontkowski

### **MEMBERSHIP** (*Elected Committee*)

Nirmal C. Tejwani (Chair)  
Richard E. Buckley  
Robert P. Dunbar, Jr.  
David W. Sanders  
Robert D. Zura

#### **International Members Committee** (**Ad Hoc Committee**)

Peter V. Giannoudis (Chair)  
Ney Amaral (Brazil)  
Guenter C. Lob (Germany)  
Akira Oizumi (Japan)  
Hans-Christoph Pape (Germany)  
Thomas A. (Toney) Russell (China focus)

### **ANNUAL MEETING ARRANGEMENTS**

David C. Templeman, Andrew H. Schmidt  
& Peter A. Cole  
(Minneapolis, MN 2012 Local Hosts)  
Laura J. Prokuski  
(Phoenix, AZ 2013 Local Host)  
Roy Sanders & H. Claude Sagi  
(Tampa, FL 2014 Local Hosts)  
David J. Hak, CFO

### **ARCHIVES**

Bruce H. Ziran (Chair)  
Alan T. Kawaguchi  
Daniel J. Stinner

### **BY-LAWS & HEARINGS**

James P. Stannard (Chair)  
Mark J. Anders  
Alexandra Schwartz

### **CLASSIFICATION AND OUTCOMES**

Craig S. Roberts (Chair)  
Gregory L. DeSilva  
Douglas R. Dirschl  
Andrew R. Evans  
Clifford B. Jones  
Douglas W. Lundy  
Gregory A. Zych  
Julie Agel (Presidential Consultant)  
James F. Kellam (Presidential Consultant)  
J. Lawrence Marsh (Presidential Consultant)

### **Open Fracture Work Group**

Milan K. Sen  
Debra L. Sietsema

### **DISASTER MANAGEMENT & EMERGENCY PREPAREDNESS**

Christopher T. Born (Chair)  
Michael J. Bosse  
Christian N. Mamczak  
Mark P. McAndrew  
Mark W. Richardson  
David C. Teague  
Philip R. Wolinsky

## **EDUCATION**

William M. Ricci (Chair)  
Paul J. Dougherty  
Samir Mehta  
Robert F. Ostrum  
Marcus F. Sciadini  
Paul Tornetta, III  
Michael Beltran (Resident Member, ex-officio)

### **Education Sub Committee**

#### **Advanced Trauma Techniques Course – February 22 - 23, 2013**

Brett D. Crist & Matthew A. Mormino  
**13th Annual AAOS/OTA Orthopaedic  
Trauma Update – April 25 - 27, 2013**  
Daniel S. Horwitz & Steven J. Morgan  
**Orthopaedic Trauma Fellows Course  
– April 18 - 21, 2013**

Paul Tornetta, III

#### **Resident Syllabus Update**

Kenneth J. Koval

#### **Comprehensive Fracture Course for Residents 2.0 – April 10 - 13, 2013**

Matt L. Graves & Gregory J. Della Rocca

#### **Comprehensive Fracture Course for Residents – October 9 - 12, 2013**

Michael T. Archdeacon & Kyle J. Jeray

**JOT Editor:** Roy Sanders

## **EVALUATION**

Andrew H. Schmidt (Pres Elect)  
Mohit Bhandari  
Mitchel B. Harris  
James P. Stannard  
Ross K. Leighton (2nd Pres Elect, ex officio)

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George J. Haidukewych  
John M. Iaquinto  
Frank A. Liporace  
Toni M. McLaurin  
Michael J. Prayson  
Roy Sanders  
Lisa A. Taitsman  
J. Tracy Watson (Presidential Consultant)  
Augusta Whitney (Resident Member)

### **Fellowship MATCH Compliance Sub Committee**

Gregory J. Schmeling (Chair)  
Animesh Agarwal  
Robert J. Brumback  
Clifford B. Jones  
Stephen A. Kottmeier

## **FINANCE AND AUDIT**

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Alan L. Jones, Past CFO  
Brendan M. Patterson

## **FUND DEVELOPMENT**

Steven J. Morgan (Chair)  
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Brendan M. Patterson  
Edward A. Perez  
Michael S. Sirkin  
Rena L. Stewart  
J. Tracy Watson  
David J. Hak, CFO (ex officio)  
Todd O. McKinley, Research Committee  
Chair (ex officio)

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Timothy J. Bray, Immediate  
Past-President  
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James A. Goulet, Annual Meeting  
Program Chair  
Michael T. Archdeacon, RCFC Chair  
Alan L. Jones, Past CFO  
Todd O. McKinley, Research Committee  
Chair

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David B. Carmack  
Alex A. Jahangir  
Clifford B. Jones  
Theodore Toan Le  
Samir Mehta  
Heather A. Vallier  
Philip R. Wolinsky

## **MILITARY**

LTC Romney C. Andersen (Chair) (Army)  
Robert J. Gaines (Navy)  
Christopher T. LeBrun (Air Force)  
LTC Joseph R. Hsu (Army)  
COL (Ret) Mark W. Richardson (Air Force)

## **PAST PRESIDENTS LIAISON**

Timothy J. Bray, Immediate Past  
President (Chair)  
All past Presidents are committee members

## **PRACTICE MANAGEMENT**

William R. Creevy (Chair)  
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David S. Brokaw  
Anthony F. Infante, Jr.  
James C. Krieg  
Brent L. Norris  
M. Bradford Henley (Presidential Consultant)

## **PROGRAM ANNUAL MEETING**

James A. Goulet (Chair)  
Thomas F. Higgins (Co-Chair)  
Victor A. de Ridder  
Michael J. Gardner  
Pierre Guy  
Michael D. McKee  
Theodore Miclau, III  
Robert V. O'Toole  
John T. Ruth

### **Program Basic Science Sub Committee**

Theodore Miclau, III (Chair)  
Mohit Bhandari  
Joseph Borrelli, Jr.  
Edward J. Harvey  
Steven A. Olson  
Emil H. Schemitsch

### **Program Masters Level Coding Course**

William R. Creevy (Chair)

## **PUBLIC RELATIONS AND BRANDING**

Jeffrey M. Smith (Chair)  
Joseph R. Cass  
Robert O. Crous, III  
Joshua L. Gary  
Alex Jahangir  
Hasaan R. Mir (Newsletter Editor)  
Max Morandi

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Lisa K. Cannada  
Brett D. Crist  
Dan Coll  
Gregory J. Della Rocca  
Robert P. Dunbar, Jr.  
George M. Kontakis  
Hassan R. Mir  
Erika J. Mitchell  
Lori K. Reed  
Edward K. Rodriguez  
Alexandra Schwartz  
Lisa A. Taitsman

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Brett D. Crist  
Gregory J. Della Rocca  
Bruce G. French  
James J. Mason  
Saam Morshed  
Brian H. Mullis  
Steven A. Olson  
George V. Russell  
Walter W. Virkus  
Robert D. Zura

## **OTA PROJECT TEAMS**

### **International Relationships**

William G. DeLong, Jr. (Chair)  
Jeffrey O. Anglen  
Peter V. Giannoudis  
Max Morandi  
Steven J. Morgan  
Saqib Rehman  
Andrew H. Schmidt  
David C. Templeman  
Lewis G. Zirkle, Jr.

### **Evidence Based Outcomes**

William T. Obremskey (Chair)  
Mohit Bhandari  
Michael J. Bosse  
Cory A. Collinge  
Douglas R. Dirschl  
Steven A. Olson  
H. Claude Sagi  
Paul Tornetta, III

## **LIAISONS**

### **AAOS BOS (American Academy of Orthopaedic Surgeons Board of Specialty Societies)**

Andrew H. Schmidt - Presidential Line Rep  
Lisa K. Cannada - Communications  
Michael Suk - Health Policy  
William M. Ricci - Education  
Todd O. McKinley – Research  
Lisa K. Cannada – BOS Match Oversight  
Committee Chair  
Mark A. Lee – BOS Match Oversight  
Committee OTA Rep  
Kathleen Caswell - Executive Director  
David C. Templeman – BOS Secretary

**ACS COT (American College of Surgeons  
Committee on Trauma)**

Gregory J. Della Rocca (2014)  
William G. DeLong, Jr. (2013)  
Gregory Georgiadis (2013)  
Douglas W. Lundy (2014)  
Gregory J. Schmeling (2015)  
Wade R. Smith (2014)  
Philip R. Wolinsky (2013)

**USBJDI**

Peter G. Trafton

**EWI**

Marc F. Swiontkowski

 **OTA DISTINGUISHED VISITING SCHOLAR PROGRAM**

OTA expresses gratitude to the following OTA/AAOS Members who have been chosen as Distinguished Visiting Scholars by a civilian/military panel to spend at least two weeks assisting the Military Orthopaedic Surgeons in Landstuhl who treat the soldiers injured in Afghanistan and Iraq prior to their return to the United States:

Lawrence B. Bone, MD  
Christopher T. Born, MD  
Joseph Borrelli, Jr., MD  
Michael J. Bosse, MD  
Andrew R. Burgess, MD  
Jens R. Chapman, MD  
Cory A. Collinge, MD  
James Dunwoody, MD  
Mitchel B. Harris, MD  
Langdon A. Hartsock, MD  
Dolfi Herscovici, Jr., MD  
Thomas F. Higgins, MD  
Daniel S. Horwitz, MD  
James J. Hutson, Jr., MD  
Kyle J. Jeray, MD

Clifford B. Jones, MD  
Jonathan P. Keeve, MD  
James C. Krieg, MD  
Jackson Lee, MD  
L. Scott Levin, MD  
David W. Lhowe, MD  
Dean G. Lorch, MD  
David W. Lowenberg, MD  
Mark P. McAndrew, MD  
Michael D. McKee, MD  
Toni M. McLaurin, MD  
Michael A. Miranda, MD  
Steven J. Morgan, MD  
Brett C. Norris, MD  
Steven A. Olson, MD

William T. Obremskey, MD  
Brendan M. Patterson, MD  
Laura J. Prokuski, MD  
Melvin P. Rosenwasser, MD  
John T. Ruth, MD  
H. Claude Sagi, MD  
Bruce J. Sangeorzan, MD  
Andrew H. Schmidt, MD  
R. Bruce Simpson, Jr., MD  
Marc F. Swiontkowski, MD  
David C. Teague, MD  
Peter G. Trafton, MD  
Bruce H. Ziran, MD  
Robert D. Zura, MD

**Landstuhl Distinguished Visiting Scholars Program: Ongoing Need for Volunteers!!**

- Over 40 Active OTA members have participated since program inception in August 2007.
- Conflict is ongoing in Afghanistan, causing many multilimb amputations and other severe trauma in US and coalition partner forces.
- Landstuhl, Germany is a critical stop over in the evacuation of casualties from the theater providing interim care but also provides definitive trauma care for certain coalition partners and contractors.
- Scholars have the opportunity to provide valuable teaching and support to military orthopaedic surgeons while gaining a unique insight to these highly complex war injuries. Recent scholars have remarked that this has been among the most rewarding experience in orthopaedics in their careers.
- Suggested scholar criteria:
  - o Demonstrated commitment to teaching and leadership in orthopaedic trauma
  - o 5 years of trauma experience following ABOS certification

**If interested please contact the OTA Business Office, and include your CV: [ota@aaos.org](mailto:ota@aaos.org)**





## IN MEMORIAM

OTA remembers the following members who have made contributions to OTA's organizational missions, to education, to the practice of orthopaedics, and to the science of musculoskeletal trauma research.

- |  |  |
|--|--|
| E. Frederick Barrick, MD (2004)<br>Mc Lean, Virginia   | Kenneth D. Johnson, MD* (2003)<br>Placitas, New Mexico     |
| Fred F. Behrens, MD (2005)<br>Newark, New Jersey       | Emile Letournel, MD (1994)<br>Paris, France                |
| John Border, MD (1997)<br>Buffalo, New York            | Alan Marc Levine, MD* (2009)<br>Baltimore, Maryland        |
| Spencer L. Butterfield, MD (2007)<br>Cincinnati, Ohio  | CDR Michael T. Mazurek, MD (2009)<br>San Diego, California |
| James Bradley Carr, MD (2011)<br>Roanoke, Virginia     | William J. Mills, III, MD (2011)<br>Anchorage, Alaska      |
| Thomas H. Comfort, MD (1990)<br>Minneapolis, Minnesota | Maurice Müeller, MD (2009)<br>Bern, Switzerland            |
| John F. Connolly, MD (2007)<br>Orlando, Florida        | John A. Ogden, MD (2011)<br>Atlanta, Georgia               |
| Kathryn E. Cramer, MD (2005)<br>Detroit, Michigan      | Howard Rosen, MD (2000)<br>New York, New York              |
| Bertram Goldberg, MD (1995)<br>Englewood, Colorado     | Joseph F. Slade, MD (2010)<br>Guilford, Connecticut        |
| Edward T. Habermann, MD (2009)<br>Chappaqua, New York  | Phillip G. Spiegel, MD (2008)<br>Englewood, Florida        |
| J. Paul Harvey, Jr., MD (2010)<br>Pasadena, California |  |

*A memorial page honoring the lives and work of OTA members  
has been established on the OTA website membership link.*

\*OTA Past President

## MEMORIAL AWARDS

OTA honors the memory of the orthopaedic traumatologists listed on page 5 in memory of their commitment to education, research and patient care.

**2011 – Rachel Y. Goldstein, MD, MPH, Resident Award Winner**  
**Δ Efficacy of Popliteal Block in Postoperative Pain Control After Ankle Fracture Fixation: A Prospective Randomized Study**

Rachel Y. Goldstein, MD, MPH; Nicole Montero, BA; Toni M. McLaurin, MD;  
Kenneth A. Egol, MD; Nirmal C. Tejwani, MD;  
NYU Hospital for Joint Diseases, New York, New York, USA

**2010 – Dirk Leu, MD, Resident Award Winner**  
**Spica Casting in Pediatric Femur Fractures: A Prospective Randomized Controlled Study of 1-Leg versus 1.5-Leg Spica Casts**

Dirk Leu, MD; Erkula Gurkan, MD; M. Catherine Sargent, MD; Michael C. Ain, MD;  
Arabella I. Leet, MD; John E. Tis, MD; Gregory M. Osgood, MD; Paul D. Sponseller, MD;  
Johns Hopkins Hospital, Baltimore, Maryland, USA

**CPT Daniel J. Stinner, MD; MAJ(P), Resident Award Winner**

**• Negative Pressure Wound Therapy (NPWT) Reduces Effectiveness of Antibiotic Beads**

CPT Daniel J. Stinner, MD, MAJ(P); LTC Joseph R. Hsu, MD; Joseph C. Wenke, MD;  
United States Army Institute of Surgical Research, Fort Sam Houston, Texas, USA

**2009 – Scott Ryan, MD (n) Resident Award Winner**  
**Knee Pain After Tibial Nailing Correlates with Union**

Paul Tornetta, III, MD (3,5A, 7-Smith & Nephew; 8-Exploramed);  
Cassandra Dietwart, MD (n); Elizabeth Krall Kaye, PhD (n);  
Boston University Medical Center, Boston, Massachusetts, USA

**2008 – Priyesh Patel, MD Resident Award Winner**  
**Transsacral Fixation: What Defines the Safe Zone?**

Paul Tornetta, III, MD; Priyesh Patel, MD; Jorge Soto, MD;  
Boston University Medical Center, Boston, Massachusetts, USA

**2007 – Michael Zlowodzki, MD Resident Award Winner**  
**Patient Function following Femoral Neck Shortening and Varus Collapse after Cancellous Screw Fixation of Isolated Femoral Neck Fractures: A Multicenter Cohort Study**

Michael Zlowodzki, MD (a-Osteosynthesis and Trauma Care Foundation; AO North America);  
Ole Brink, MD, PhD (n); Julie Switzer, MD (n); Scott Wingerter, MD (n);  
James Woodall Jr., MD (n); David R. Bruinsma (n); Brad A. Petrison, MD (n);  
Philip J. Kregor MD (n); Mohit Bhandari, MD, MSc (n);  
University of Minnesota, Minneapolis, Minnesota, USA

For two years, the OTA instituted a Kenneth D. Johnson Fellowship Award to honor the memory of the contributions to the field of Orthopaedic Traumatology by founding member and past-president, Kenneth D. Johnson, MD. Dr. Johnson is remembered as an academic instructor skilled in teaching and passionate about the work of the OTA and improving the treatment for trauma patients.

**2006 – Marc A. Tressler, DO, Kenneth D. Johnson Fellowship Award**  
Vanderbilt University Fellowship Program, Nashville, Tennessee, USA;  
Hosted by Harborview Medical Center, Seattle, Washington, USA

**2005 – Max Talbot, MD, Kenneth D. Johnson Fellowship Award**  
University of Minnesota, Fellowship Program, Minneapolis, Minnesota, USA;  
Hosted by Emil H. Schemitsch, MD, University of Toronto, Toronto, Ontario, Canada

## OTA/SIGN SCHOLARSHIP

The Orthopaedic Trauma Association Board of Directors, approved granting two scholarships annually for SIGN members to attend the OTA annual meeting. Information regarding SIGN can be found on <http://www.sign-post.org>.

### **Congratulations to the following OTA/SIGN Scholarship Winners:**

- 2012** – *Dr. Shahab ud Din, Hayatabad, Peshawar, KPK, Pakistan*  
*Dr. Luigi Andrew Sabal, Bajada, Davao City, Philippines*
- 2011** – *Dr. Tobias Otieno Ondiek, Kijabe, Kenya*  
*COL. Mohammad Ismail Wardak, MD, MS, Kabul, Afghanistan*
- 2010** – *Edmund Ndalama Eliezer, MD, Dar es Salaam, Tanzania*
- 2009** – *Rizwan Akram, MD, Lahore, Punjab, Pakistan*  
*Patrick Sekimpi, MD, Kampala, Uganda*
- 2008** – *Duong Bunn, MD, Phnom Penh, Cambodia*  
*Oleg Gendin, MD, Krasnoyarsk, Russia*
- 2007** – *Thwit Lwin, MD, Yangon, Myanmar*  
*Kibor Leilei, MD, Eldoret, Kenya*

## FOUNDERS' LECTURE

- 2001** – **Honoring the Career of Michael W. Chapman, MD**  
**Recent Advances in the Cellular and Molecular Biology of Post Traumatic Arthritis**  
*A. Hari Reddi, PhD*  
*(Supported by Howmedica)*
- 2000** – **A Tribute to Howard Rosen, MD — Standing on the Shoulders of Giants**  
*Joseph Schatzker, MD*

## JOHN BORDER, MD, MEMORIAL LECTURE

*Supported in part by AO/North America and OTA*

This lectureship was established to honor the memory of Dr. John Border. John Border was instrumental in the development of modern trauma care and in particular, modern orthopaedic trauma care. He was the pioneer in the concept of total care and the implications of the orthopaedic injuries on the total management of the trauma patient. He was also a surgeon scientist, using both his clinical observations and basic science research to further his patient care in Orthopaedic Trauma.

- 2011 – **Femoral Neck Fracture Management - WWJD (John)?**  
*Marc F. Swiontkowski, MD*
- 2010 – **Travels with John 2.0**  
*Sigvard T. Hansen, Jr., MD*
- 2009 – **“Trauma Surgery Is Not Supposed To Be Easy”**  
*Lawrence B Bone, MD*
- 2008 – **Orthopaedic Trauma Education: Industrial Strength?**  
*Peter G. Trafton, MD*
- 2007 – **Once and Future Trauma Systems: Role of the Orthopaedic Surgeon**  
*A. Brent Eastman, MD, FACS*
- 2006 – **Forty Years of Pelvic Trauma – Looking Back, Looking Forward**  
*Marvin Tile, MD*
- 2005 – **Delaying Emergency Fracture Care – Fact or Fad**  
*Robert N. Meek, MD*
- 2004 – **The Future of Education in Orthopaedic Surgery**  
*Michael W. Chapman, MD*
- 2003 – **Tracking Patient Outcomes: Lessons Learned and Future Directions in Trauma Orthopaedics**  
*Ellen J. MacKenzie, PhD*
- 2002 – **Thoughts on Our Future Progress in Acetabular and Pelvic Fracture Surgery**  
*Joel M. Matta, MD*
- 2001 – **Cancelled**
- 2000 – **The Metamorphosis of the Trauma Surgeon to the Reconstructionist**  
*Jeffrey W. Mast, MD*
- 1999 – **The Changing Role of Internal Fixation – A Lifetime Perspective**  
*Professor Martin Allgower, MD*
- 1998 – **Travels with John: Blunt Multiple Trauma**  
*Sigvard T. Hansen, MD*
- 1997 – **Trauma Care in Europe before and after John Border: The Evolution of Trauma Management at the University of Hannover**  
*Professor Harald Tscherne, MD*

## EDWIN G. BOVILL, Jr., MD AWARDS

*Dedicated to Edwin G. Bovill, Jr., MD, (1918 - 1986)  
Surgeon, traumatologist, educator, academician, and gentleman;  
co-founder of the Orthopaedic Trauma Association.*



(The outstanding scientific paper from the Annual Meeting date as listed.)

### 2011 – Posterolateral Antiglidle Versus Lateral Plating for SE Pattern Ankle Fractures: A Multicenter Randomized Control Trial

*Paul Tornetta, III, MD<sup>1</sup>; Laura S. Phieffer, MD<sup>2</sup>; Clifford B. Jones, MD<sup>3</sup>; Janos P. Ertl, MD<sup>4</sup>; Brian H. Mullis, MD<sup>4</sup>; Kenneth A. Egol, MD<sup>5</sup>; Michael J. Gardner, MD<sup>6</sup>; William M. Ricci, MD<sup>6</sup>; David C. Teague, MD<sup>7</sup>; William Ertl, MD<sup>7</sup>; Cory A. Collinge, MD<sup>8</sup>; Ross K. Leighton, MD<sup>9</sup>; Ojas Joshi, MS<sup>1</sup>*

<sup>1</sup>Boston University Medical Center, Boston, Massachusetts, USA;

<sup>2</sup>Ohio State University Medical Center, Columbus, Ohio, USA;

<sup>3</sup>Orthopaedic Associates of Michigan, Grand Rapids, Michigan, USA;

<sup>4</sup>Indiana University, Indianapolis, Indiana, USA;

<sup>5</sup>NYU Hospital for Joint Disease, New York, New York, USA;

<sup>6</sup>Washington University, St. Louis, Missouri, USA

<sup>7</sup>University of Oklahoma, Oklahoma City, Oklahoma, USA;

<sup>8</sup>Orthopaedic Associates – Fort Worth, Fort Worth, Texas, USA;

<sup>9</sup>Halifax Infirmary, Halifax, Nova Scotia, Canada

### Δ Efficacy of Popliteal Block in Postoperative Pain Control After Ankle Fracture Fixation: A Prospective Randomized Study

*Rachel Y. Goldstein, MD, MPH; Nicole Montero, BA; Toni M. McLaurin, MD; Kenneth A. Egol, MD; Nirmal C. Tejwani, MD  
NYU Hospital for Joint Diseases, New York, New York, USA*

### 2010 – Operative versus Nonoperative Treatment of Unstable Lateral Malleolar Fractures: A Randomized Multicenter Trial

*David W. Sanders, MD (3B, 5-Smith & Nephew Richards Canada; 5-Synthes Canada); Christina A. Tieszer (n); Canadian Orthopedic Trauma Society (n); University of Western Ontario, London, Ontario, Canada*

### 2009 – Nonoperative Immediate Weightbearing of Minimally Displaced Lateral Compression Sacral Fractures Does Not Result in Displacement

*Gillian Sembler, MD (n); John Lien, MD (n); Paul Tornetta, III, MD (3, 5A, 7-Smith & Nephew; 8-Exploramed); Boston University Medical Center, Boston, Massachusetts, USA*

### 2008 – Piriformis versus Trochanteric Antegrade Nailing of Femoral Fractures: A Prospective Randomized Study

*James P. Stannard, MD (a-Smith + Nephew, Synthes); David A. Volgas, MD (a-Biomet (Interport-Cross), Smith + Nephew, Synthes, Pfizer); Larry S. Bankston, MD (n); Jonathan K. Jennings (n); Rena L. Stewart, MD (a-Synthes, Wyeth, OTA); Jorge E. Alonso, MD (e-Synthes); The University of Alabama at Birmingham, Birmingham, Alabama, USA*

### 2007 – A Randomized Trial of Reamed versus Non-Reamed Intramedullary Nail Insertion on Rates of Reoperation in Patients with Fractures of the Tibia

*Mohit Bhandari, MD (n); McMaster University, Hamilton, Ontario, Canada*

EDWIN G. BOVILL, Jr., MD AWARDS, *continued*

**2006 – Δ A Multicenter Prospective Randomized Controlled Trial of Open Reduction and Internal Fixation versus Total Elbow Arthroplasty for Displaced Intra-articular Distal Humeral Fractures in Elderly Patients**

*Michael D. McKee, MD; Christian J.H. Veillette, MD; and the Canadian Orthopaedic Trauma Society: Emil H. Schemitsch, MD; Jeremy A. Hall, MD; Lisa M. Wild, BScN; Robert McCormack, MD; Thomas Goetz, MD; Bertrand Perey, MD; Mauri Zomar, RN; Karyn Moon, RN; Scott Mandel, MD; Shirley Petit, RN; Pierre Guy, MD; Irene Leung, BScPT; (all authors - a-OTA/Zimmer Grant)  
St. Michael's Hospital, University of Toronto, Toronto, Ontario, Canada  
(Δ-OTA/Aventis Pharmaceuticals)*

**2005 – Δ A Multicenter Randomized Control Trial of Non-Operative and Operative Treatment of Displaced Clavicle Shaft Fractures**

*Michael D. McKee, MD, FRCS(C); Jeremy A. Hall, MD, FRCS(C); and the Canadian Orthopaedic Trauma Society: Hans S. Kreder, MD; Robert McCormack, MD; David M.W. Pugh, MD; David W. Sanders, MD; Richard Buckley, MD; Emil H. Schemitsch, MD; Lisa M. Wild, RN; Scott Mandel, MD; Rudolph Reindl, MD; Edward J. Harvey, MD; Milena V. Santos, RN; Christian J. Veillette, MD; Daniel B. Whelan, MD; James P. Waddell, MD; David J.G. Stephen, MD; Terrence Axelrod, MD; Gregory Berry, MD; Bertrand Perey, MD; Kostas Panagiotopoulos, MD; Beverly Bulmer, Mauri Zomar; Karyn Moon, Elizabeth Kimmel, Carla Erho, Elena Lakoub; Patricia Leclair; Bonnie Sobachak; Trevor Stone, MD; Lynn A. Crosby, MD; Carl J. Basamania, MD; (all authors a-OTA/DePuy Grant; Zimmer, Inc. Grant)  
St. Michael's Hospital, University of Toronto, Toronto, Ontario, Canada  
(Δ-OTA/DePuy, a Johnson and Johnson Company)*

**2004 – The Gold Standard in Tibial Plateau Fractures? A Prospective Multicenter Randomized Study of AIBG vs. Alpha-BSM**

*Thomas A. Russell, MD; Sam Agnew, MD; B. Hudson Berrey, MD; Robert W. Bucholz, MD; Charles N. Cornell, MD; Brian Davison, MD; James A. Goulet, MD; Thomas Gruen, MS; Alan L. Jones, MD; Ross K. Leighton, MD (a-DePuy, USA; a,b,e-ETEX); Peter O'Brien, MD; Robert F. Ostrum, MD; Andrew Pollak, MD; Paul Tornetta, III, MD; Thomas F. Varecka, MD; Mark S. Vrahas, MD*

**2003 – Previously Unrecognized Deficits after Nonoperative Treatment of Displaced, Mid-Shaft Fracture of the Clavicle Detected by Patient-Based Outcome Measures and Objective Muscle Strength Testing**

*Michael D. McKee, MD, FRCS(C); Elizabeth M. Pedersen, MD; Lisa M. Wild, BScN; Emil H. Schemitsch, MD, FRCS(C); Hans J. Kreder, MD; David J.G. Stephen, MD, FRCS(C)  
(a-University of Toronto Scholarship Fund)*

**Syndesmotic Instability in Weber B Ankle Fractures: A Clinical Evaluation**

*Paul Tornetta, III, MD; Erik Stark, MD; William R. Creevy, MD  
(a-Stryker Howmedica Osteonics)*

**2002 – A Randomized Controlled Trial of Indirect Reduction and Percutaneous Fixation versus Open Reduction and Internal Fixation for Displaced Intraarticular Distal Radius Fractures**

*Hans J. Kreder, MD, FRCS(C); Douglas P. Hanel, MD; Julie Agel, MA, ATC;  
Michael D. McKee,*

**2001 – Pertrochanteric Fractures: Is There an Advantage to an Intramedullary Nail?**

*Richard E. Stern, MD; Christophe Sadowski, MD; Anne Lübbecke, MD; Marc Saudan, MD; Nicolas Riand, MD; Pierre Hoffmeyer, MD,*

**\*Stress Examination of SE-Type Fibular Fractures**

*Paul Tornetta, III, MD; Timothy McConnell, MD; William R. Creevy, MD  
(all authors – a-Aircast Foundation)*

**EDWIN G. BOVILL, Jr., MD AWARDS, *continued***

- 2000 – Δ Prospective Randomized Clinical Multi-Center Trial: Operative versus Nonoperative Treatment of Displaced Intra-Articular Calcaneal Fractures**  
*Richard E. Buckley, MD; Robert G. McCormack, MD; Ross K. Leighton, MD; Graham C. Pate, MD; David P. Petrie, MD; Robert D. Galpin, MD*  
(Δ-OTA Administered Research Grant)
- 1999 – Δ The Effect of Sacral Malreduction on the Safe Placement of Iliosacral Screws**  
*Mark Cameron Reilly, MD; Christopher M. Bono, MD; Behrang Litkoihi, BS; Michael S. Sirkin, MD; Fred Behrens, MD*  
(Δ-OTA Administered Research Grant)
- 1998 – A Prospective Comparison of Antegrade and Retrograde Femoral Intramedullary Nailing**  
*Robert F. Ostrum, MD; Animesh Agarwal, MD; Ronald Lakatos, MD; Attila Poka, MD*
- 1997 – Accelerated Bone Mineral Loss following a Hip Fracture: A Prospective Longitudinal Study**  
*Douglas R. Dirschl, MD; Richard C. Henderson, MD, PhD; Ward C. Oakley, MD*
- 1996 – None Awarded**
- 1995 – Safe Placement of Proximal Tibial Transfixation Wires with Respect to Intracapsular Penetration**  
*J. Spence Reid, MD; Mark Vanslyke; Mark J.R. Moulton; Thomas Mann, MD*
- 1994 – Compartment Pressure Monitoring in Tibial Fractures**  
*Margaret M. McQueen, FRCS; James Christie, FRCS; Charles M. Court-Brown, MD, FRCS*
- 1993 – The Intraoperative Detection of Intraarticular Screws Placed during Acetabular Fracture Fixation**  
*Thomas DiPasquale, DO; Kurt Whiteman; C. McKirgan; Dolfi Herscovici*
- 1992 – Operative Results in 120 Displaced Intra-Articular Calcaneal Fractures: Results Using a Prognostic CAT Scan Classification**  
*Roy Sanders, MD; Paul Fortin, MD; Thomas DiPasquale, DO*
- 1991 – Severe Open Tibial Shaft Fractures with Soft Tissue Loss Treated by Limb Salvage with Free Tissue Transfer or Early Below Knee Amputation**  
*Gregory Georgiadis, MD; Fred Behrens, MD; M. Joyce; A. Earle*
- 1990 – Timing of Operative Intervention in the Management of Acute Spinal Injuries**  
*J. Schlegel; H. Yuan; B. Frederickson; J. Bailey*

## ACKNOWLEDGMENTS

The Orthopaedic Trauma Association gratefully acknowledges the following companies and individuals for their generous financial support received through OTA and through OREF to fund OTA reviewed research grants and educational programs.

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#### 2011 OREF/OTA ENDOWMENT FUND CONTRIBUTIONS

Joseph Cass, Fred Kolb, James Nepola, David Weisman, Bruce Ziran

CENTER FOR ORTHOPAEDIC TRAUMA ADVANCEMENT  
ACKNOWLEDGMENTS



COTA is grateful for the financial support during 2012 from  
*Smith & Nephew, Inc.* and *Stryker Orthopaedics.*



COTA supported fellowship programs for the 2012-2013 academic year as follows:

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*Daniel T. Altman, MD, Director*

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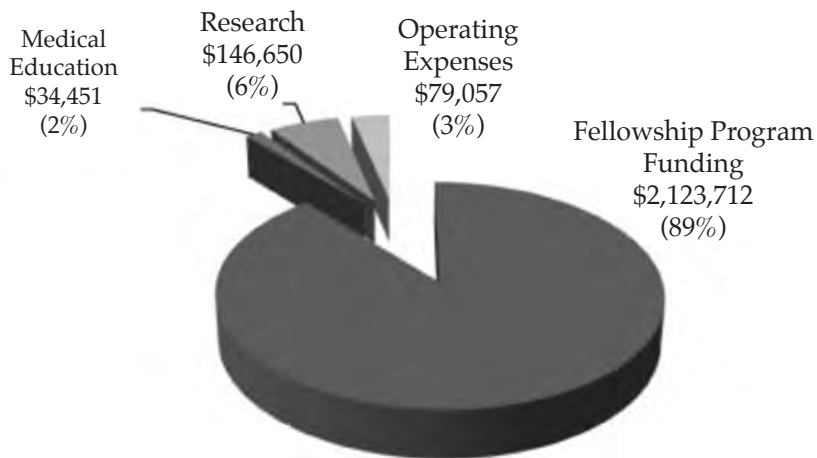
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*Eben Carroll, MD, Director*

- **17 Fellowship Grants accepted for 2012-2013 = \$1,175,000**
- **\$28,230 additional funds for Orthopaedic Trauma Education 2011**
- **\$236,000 for research conducted in 2011 and 2012**



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## OTA 2012 RESEARCH GRANT AWARD RECIPIENTS

### CLINICAL GRANT APPLICATIONS

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**Title: Reamer Irrigator Aspirator (RIA) Versus Autogenous Iliac Crest Bone Graft (AICBG) for the Treatment of Nonunions: A Randomized, Prospective, Multi-Centre, Clinical Trial**

Principal Investigator: Aaron Nauth

Co-Principal Investigator: Emil Schemitsch

Grant Funded by: DePuy, A Johnson & Johnson Company/OTA

**Title: Negative Pressure therapy Dressings Versus Standard Dressings for Closed Calcaneus Fractures: A Prospective Randomized Study of Wound Complications & Infection**

Principal Investigator: Michael Archdeacon

Co-Principal Investigator: Camille Connelly

Grant Funded by: OTA

**Title: A Cognitive Behavioral Relaxation Response Training Intervention for Patients At Risk With History of Orthopedic Musculoskeletal Trauma**

Principal Investigator: Ana-Maria Vranceanu

Co-Principal Investigator: David Ring

Grant Funded by: Smith & Nephew/OTA

### BASIC RESEARCH GRANTS

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**Title: Antimicrobial Photodynamic Therapy for Prevention and Treatment of Surgical Site Infections**

Principal Investigator: Tianhong Dai

Co-Principal Investigator: Mark Vrahas

Grant Funded by: OTA

**Title: Bone Tissue Engineering Using a Scaffold Seeded With VEGF - Transfected Osteoblasts**

Principal Investigator: Ru Li

Co-Principal Investigator: Emil Schemitsch

Grant Funded by: OTA

**Title: Adipose Derived Stem Cells In the Treatment of Fractures With Bone Loss and Nonunions**

Principal Investigator: Robert Ostrum

Co-Principal Investigator: Thimas Tulenko

Grant Funded by: OTA

**Title: Expression of Single Nucleotide Polymorphisms in Delayed Fracture Healing**

Principal Investigator: John Reid

Co-Principal Investigator: Vikram Sathyendra

Grant Funded by: OTA

**Title: Role Of Carbon Monoxide (CO), Liberated from a Novel CO-Releasing Molecule (CORM-3) In the Protection of Skeletal Muscle Following Compartment Syndrome**

Principal Investigator: Abdel-Rahman Lawendy

Grant Funded by: OTA

## OTA 2012 RESEARCH GRANT AWARD RECIPIENTS

### **BASIC RESEARCH GRANTS**, continued

---

**Title: Traumatic Cauda Equina Compression: The Relationship Between the Duration of Compression, Inflammation and Functional Outcomes In a Rat Model**

Principal Investigator: **Chris Bailey**

Co-Principal Investigator: **David Sanders**

Grant Funded by: **OTA**

**Title: Novel Therapeutic Approach To Improve Bone Healing By Increasing Vascularity of a Fracture Site Through the Application of Trophoblast Stem Cells**

Principal Investigator: **Chelsea Bahney**

Co-Principal Investigator: **Theodore Miclau**

Grant Funded by: **OTA**

**Title: The Role of G Protein-Coupled Estrogen Receptor 1 In the Fracture Healing of Normal and Oophorectomized Mice**

Principal Investigator: **Rahul Banerjee**

Co-Principal Investigator: **Brigham Au**

Grant Funded by: **Zimmer/OTA**

## OTA 2012 RESIDENT GRANT AWARD RECIPIENTS

(January 1 - December 31, 2012 Grant Cycle)

### \$10,000 RESIDENT GRANT RECIPIENTS

---

Principal Investigator: **Scott Koenig, MD**; Co-Investigator: **Paul Tornetta, MD**  
Grant Title: **Analysis of Lateral Fluoroscopic Imaging To Assess the Quality of Ankle Syndesmotic Reduction**  
Grant Funded by: **COTA/Smith-Nephew**

Principal Investigator: **Tom Chao, MD**; Co-Investigator: **David P. Zamorano, MD**  
Grant Title: **A Novel Method for Preservation of the Neuromuscular Junction Using An Inhibitor To MMP-3**  
Grant Funded by: **DePuy/OTA**

Principal Investigator: **Alison Kitay, MD**; Co-Investigator: **Charles N. Cornell, MD**  
Grant Title: **The Canonical Wnt Signaling Pathway Plays a Critical Role In the Etiology of Age-Related Impaired Fracture Healing**  
Grant Funded by: **COTA/Smith-Nephew**

Principal Investigator: **Clifford Lin, MD**; Co-Investigator: **Emil Schemitsch, MD**  
Grant Title: **Effects of Endothelial Progenitor Cell Therapy on Diabetic Rat Fracture Healing**  
Grant Funded by: **OTA**

Principal Investigator: **Adam Wilson, MD**; Co-Investigator: **Francis H. Shen, MD**  
Grant Title: **Human Adipose-Derived Stem Cells In Three-Dimensional Multicellular Aggregates As Autograft for Spinal Fusion: An In Vitro and In Vivo Study**  
Grant Funded by: **Zimmer/OTA**

Principal Investigator: **David Wasserstein, MD**; Co-Investigator: **Richard Jenkinson, MD**  
Grant Title: **Complications and Re-Operation After Tibial Plateau Fracture Fixation In A Large Population Cohort**  
Grant Funded by: **OTA**

Principal Investigator: **Scott Yang, MD**; Co-Investigator: **Quanjun Cui, MD**  
Grant Title: **Modulation of the Host Immune Response To Enhance Efficacy of Allogeneic Mesenchymal Stem Cells**  
Grant Funded by: **OTA**

Principal Investigator: **Jonathan Chae, MD**; Co-Investigator: **Eric S. Moghadamian, MD**  
Grant Title: **Biomechanical Analysis of Novel "Pauwels" Screw Fixation for Pauwels Type-III Vertical Sheer Femoral Neck Fractures**  
Grant Funded by: **COTA/Smith-Nephew**

Principal Investigator: **Tarek Sibai, MD**; Co-Investigator: **Paul Tornetta, MD**  
Grant Title: **A Pilot Study To Identify A Novel Radiographic View for Types 3 and 5 Acromio-Clavicular Joint Separations Predictive Of Long-Term Outcomes**  
Grant Funded by: **OTA**

Principal Investigator: **Daniel Stinner, MD**; Co-Investigator: **Joseph R. Hsu, MD**  
Grant Title: **Can Objective Feedback Improve Patient Centered Outcomes? A Prospective Randomized Study**  
Grant Funded by: **Smith & Nephew/OTA**

## OTA 2011 RESIDENT GRANT AWARD RECIPIENTS

(June 1, 2012 - May 31, 2013 Grant Cycle)

### \$10,000 RESIDENT GRANT RECIPIENTS

---

Principal Investigator: **Justin Haller, MD**  
Co-Investigator: **Thomas Higgins, MD**  
Grant Title: **Inflammatory Response Following Intra-articular Fracture**  
Grant Funded by: **OTA**

Principal Investigator: **Michael Willey, MD**  
Co-Investigator: **Todd McKinley, MD**  
Grant Title: **Articulated Joint Distraction in a Rabbit Knee Model of Post-Traumatic Osteoarthritis**  
Grant Funded by: **OTA**

Principal Investigator: **David Shearer, MD**  
Co-Investigator: **Saam Morshed, MD**  
Grant Title: **Intramedullary Nailing Versus Plates for Femoral Shaft Fractures in Dar es Salaam, Tanzania with Minimum 1-Year Follow Up**  
Grant Funded by: **OTA**

Principal Investigator: **Timothy Alton, MD**  
Co-Investigator: **Sean Nork, MD**  
Grant Title: **Skeletal Accumulation of Bisphosphonate Impairs Bone Healing**  
Grant Funded by: **OTA**

Principal Investigator: **Stephen Gould, MD**  
Co-Investigator: **Kenneth Egol, MD**  
Grant Title: **Long Term Outcome of Surgery for Fractures of the Ankle**  
Grant Funded by: **OTA**

Principal Investigator: **Michael Beebe, MD**  
Co-Investigator: **Thomas Higgins, MD**  
Grant Title: **A Descriptive Cohort Analysis of Gonadal Radiation Exposure and Risk Secondary to Fluoroscopic Imaging During Trauma Surgery about the Pelvis and Femur**  
Grant Funded by: **OTA**

**OTA GRATEFULLY ACKNOWLEDGES  
THE FOLLOWING EXHIBITORS  
FOR THEIR SUPPORT OF THE 28<sup>TH</sup> ANNUAL MEETING:**

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414	Invuity Inc	San Francisco, CA
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ODI	Orthopedic Designs North America	Tampa, FL
300	Orthopedics Today and Healio.Com By SLACK Incorporated	Thorofare, NJ
PACIFI	Pacific Instruments	Honolulu, HI
807	PFS Med, Inc	Springfield, OR
806	Quintus Composites	Camp Verde, AZ
618	RTI Biologics Inc	Alachua, FL



## EXHIBITORS LISTING, continued

<u>Booth #</u>	<u>Company Names</u>	<u>City, State</u>
514	Sawbones/Pacific Research Labs	Vashon, WA
311	Shanghai Bojin Electric Instrument & Device Co Ltd	Shanghai, China
615	Skeletal Dynamics	Miami, FL
100	Smith & Nephew Inc	Cordova, TN
SONOM	Sonoma Orthopedic Products Inc	Santa Rosa, CA
524	Starr Frame LLC	Richardson, TX
400	Stryker	Mahwah, NJ
309	Synergy Medical Products Inc	Newport Beach, CA
701	Synthes	West Chester, PA
AOA	The American Orthopaedic Association/ Own the Bone	Rosemont, IL
408	Toby Orthopaedics LLC	Coral Gables, FL
808	Tornier	Bloomington, MN
325	TriMed, Inc.	Santa Clarita, CA
510	Twin Star ECS	Minneapolis, MN
WOUND	Wound Care Technologies Inc	Chanhassen, MN
432	Zimmer	Warsaw, IN
906	Zyga Technology Inc	Minneapolis, MN

**Maximum Map Size:  
5.5" w x 4.5 " h**

**NEED**

## OTA's ANNUAL GUEST NATION ~ MEXICO

In recognition of the importance and benefits of sharing knowledge and experience with international colleagues, the OTA has instituted a Guest Nation Program. We are proud to announce that Mexico has been selected as the 2nd Annual OTA Annual Guest Nation.



Representatives from the *Congreso Nacional de Ortopedia y Traumatología* will participate in the following symposium:  
Comparing Trauma Systems from Two Nations: China and Mexico.

Mexico: Fryda Medina, MD  
Fernando de la Huerta, MD  
Graciela Gallardo Garcia, MD

China: Jiaying Xu, MD  
Manyi Wang, MD

In addition, Ana Luisa Fajer, Cónsul of México in St. Paul, Minnesota, will attend the International Trauma Care Forum as a representative of the Embassy of Mexico.

We are pleased to have this opportunity for collaboration with our Mexican colleagues, and it will be an honor to recognize their contributions and achievements.

### **International Trauma Care Forum**

*(Convention Center DE)*

Wednesday, October 3 – 7:45 am - 5:00 pm

### **Guest Nation Symposium**

*(Convention Center DE)*

Wednesday, October 3 – 4:00 - 5:00 pm  
Evidence Based Practice in Orthopaedics

### **OTA International Reception**

Wednesday, October 3 – 5:15 - 6:15 pm

*(The Seasons – Level 2)*

All International Attendees Invited



## 2012 BASIC SCIENCE FOCUS FORUM WEDNESDAY, OCTOBER 3, 2012

6:30 am            **Registration**  
*(Convention Center Foyer Ballroom AB)*

**Continental Breakfast**  
*(Outside Meeting Event)*

**Speaker Ready Room**  
*(Convention Center 101 AB)*

7:25 am            **Introduction** *(Convention Center 101 AB)*  
*Theodore Miclau, III, MD, Program Chair*

**SYMPOSIUM 1:  
 BIOMECHANICALLY-DIRECTED FIXATION:  
 HOT TOPICS**

7:30 –  
8:40 am

(Notes p. )       Moderators: *Emil H. Schemitsch, MD*  
*Joan E. Bechtold, PhD*

7:30 am            **Clavicle Plating: Should It Be Superior or Anterior?**  
*Michael D. McKee, MD*

7:38 am            **Proximal Humerus: What Is the Ideal Fixation Construct?**  
*Michael J. Gardner, MD*

7:46 am            **Distal Humerus: Parallel or Perpendicular Plating?**  
*Emil H. Schemitsch, MD*

7:54 am            **Nail vs. Plating for IT Hip Fractures: What Is the Biomechanical Evidence?**  
*Kenneth A. Egol, MD*

8:02 am            **Distal Femur: Retrograde Nail or Locked Plate?**  
*Philip J. Kregor, MD*

8:10 am            **Proximal Tibia: How Many Plates are Enough?**  
*Philip R. Wolinsky, MD*

8:18 am            Discussion

Key: Δ = presentation was funded by an OTA administered grant  
**Names in bold = Presenter**

See pages 97 - 144 for financial disclosure information.

• The FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an "off label" use). For full information, refer to page 619.

**PAPER SESSION 1:  
BIOMECHANICALLY-DIRECTED FIXATION:  
HOT TOPICS**

8:40 –  
9:38 am

Moderators: *Emil H. Schemitsch, MD*  
*Joan E. Bechtold, PhD*

8:40 am

**Overview**

*Joan E. Bechtold, PhD*

8:50 am

(p. )

PAPER #1

**Biomechanics of Short-Segment Fixation in an Unstable Thoracolumbar Flexion-Distraction Injury Model: Six-Screw Construct With and Without Facet Compression**

*Robert P. Norton, MD<sup>1</sup>; Edward L. Milne<sup>2</sup>; David N. Kaimrajh, MS<sup>2</sup>;  
Frank J. Eismont, MD<sup>1</sup>; Loren L. Latta, MD, PhD<sup>1,2</sup>; Seth K. Williams, MD<sup>1</sup>;  
<sup>1</sup>Department of Orthopaedics, University of Miami, Miami, Florida, USA;  
<sup>2</sup>Max Biedermann Institute for Biomechanics, Miami Beach, Florida, USA*

8:56 am

(p. )

PAPER #2

**Optimizing the Biomechanics of Iliosacral Screw Fixation: The Importance of Washers and Avoiding Lateral Cortex Perforation**

*Julius A. Bishop, MD; Anthony W. Behn, MS; Tiffany N. Castillo, MD;  
Stanford University Medical Center, Palo Alto, California, USA*

9:02 am

(p. )

PAPER #3

**Screw Stripping: Can We Trust the “Bailout” Screw?**

*Amir Matityahu, MD; Gudrun Mirick, MD; Meir Marmor, MD;  
Orthopaedic Trauma Institute, San Francisco General Hospital,  
University of California San Francisco, San Francisco, California, USA*

9:08 am

Discussion

9:14 am

(p. )

PAPER #4

**Intertrochanteric Fracture Optimal Lag Screw Placement Revisited: A Biomechanical Study**

*Patrick M. Kane, MD<sup>1</sup>; Wendell M.R. Heard, MD<sup>2</sup>; Nikhil Thakur, MD<sup>3</sup>;  
David Paller, MS<sup>4</sup>; Sarath Koruprolu, MS<sup>4</sup>; Christopher T. Born, MD<sup>1</sup>;  
<sup>1</sup>Department of Orthopaedic Surgery, Brown University, Rhode Island Hospital,  
Providence, Rhode Island, USA;  
<sup>2</sup>Department of Orthopaedic Surgery, Rush University Medical Center,  
Chicago, Illinois, USA;  
<sup>3</sup>Department of Orthopaedic Surgery, Emory University, Atlanta, Georgia, USA;  
<sup>4</sup>RIH Orthopaedics Foundation, Inc, Providence, Rhode Island, USA*

## Basic Science Focus Forum – WEDNESDAY, OCTOBER 3, 2012

- 9:20 am (p. ) PAPER #5 **Biomechanical Measurements of Cyclic Preconditioning on Cadaveric Whole Canine Femurs**  
*Emil H. Schemitsch, MD<sup>1,2</sup>; Chris H. Gallimore, MD<sup>2</sup>; Alison J. McConnell<sup>3</sup>; Harshita Patel, DDS<sup>4</sup>; Rosane Nisenbaum, PhD<sup>5</sup>; Golam Morshed<sup>4</sup>; Henry Koo, MD<sup>6</sup>; Michael D. McKee, MD<sup>2</sup>; Habiba Bougherara, PhD<sup>2</sup>; Rad Zdero, PhD<sup>1,4</sup>;*  
<sup>1</sup>Biomechanics Laboratory, St. Michael's Hospital, Toronto, Ontario, Canada;  
<sup>2</sup>Department of Surgery, Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada;  
<sup>3</sup>Medtronic International Trading Sàrl, Tolochenaz, Switzerland;  
<sup>4</sup>Department of Mechanical and Industrial Engineering, Ryerson University, Toronto, Ontario, Canada;  
<sup>5</sup>Centre for Research on Inner City Health, Applied Health Research Centre, St. Michael's Hospital, Toronto, Ontario, Canada;  
<sup>6</sup>Collingwood General and Marine Hospital, Collingwood, Ontario, Canada
- 9:26 am (p. ) PAPER #6 **Mechanical Behavior and Failure Mode for Cross-Threaded Locking Screws**  
*Jacob L. Cartner, MS, Tim Petteys, MS<sup>1</sup>; Paul Tornetta III, MD<sup>2</sup>;*  
<sup>1</sup>Smith & Nephew, Memphis, Tennessee, USA;  
<sup>2</sup>Boston University School of Medicine, Boston, Massachusetts, USA
- 9:32 am Discussion
- 9:38 am Break

9:55 –  
11:05 am

**SYMPOSIUM 2:  
VENOUS THROMBOEMBOLISM**

- (Notes p. ) Moderators: *Steven A. Olson, MD*  
*William H. Geerts, MD*
- 9:55 am **Prophylaxis in Trauma Patients: What is the Standard?**  
*H. Claude Sagi, MD*
- 10:05 am **Thromboembolic Agents: The Present and the Future**  
*William H. Geerts, MD*
- 10:20 am **Current Public Reported Metrics for VTE Prophylaxis: Are they Optimal?**  
*Steven A. Olson, MD*
- 10:30 am **VTE and PE Treatment: Current Recommendations**  
*Robert D. Zura, MD*
- 10:45 am Discussion

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11:05 –  
11:39 am

**PAPER SESSION 2:  
VENOUS THROMBOEMBOLISM**

Moderators: *Steven A. Olson, MD*  
*William H. Geerts, MD*

11:05 am

**Overview**

*William H. Geerts, MD*

11:15 am

(p. )  
PAPER #7

**Nottingham Trauma Symptomatic Venous Thromboembolism Risk Score (NotSVTE): Predicting Venous Thromboembolism in Acute Trauma Admissions. A Multicenter Validated Risk Score Based on 13,347 Serial Admissions**

*Benjamin J. Ollivere, FRCS, MBBS, MD<sup>1</sup>; Katie E. Rollins, MBBS<sup>1</sup>;*

*E. Paul Szypryt, MBBS<sup>2</sup>; Christopher G. Moran, MD, FRCS<sup>1</sup>;*

*Philip Johnston, MD<sup>1</sup>; James M Hunter, MD<sup>2</sup>;*

<sup>1</sup>Cambridge University Teaching Hospitals NHS Trust

<sup>2</sup>Nottingham University Teaching Hospitals NHS Trust;

11:21 am

(p. )  
PAPER #8

**Δ Pulmonary Complications Are Reduced With a Protocol to Standardize Timing of Fixation Based on Response to Resuscitation**

*Heather A. Vallier, MD; Timothy A. Moore, MD; John J. Como, MD;*

*Patricia A. Wilczewski, RN, BSN; Michael P. Steinmetz, MD; Karl G. Wagner, MD;*

*Charles E. Smith, MD; Xiaofeng Wang, PhD; Andrea J. Dolenc, BS;*

*MetroHealth Medical Center, Cleveland Ohio, USA*

11:27 am

(p. )  
PAPER #9

**Treatment and Complications in Orthopaedic Trauma Patients With Pulmonary Embolism**

*Yelena Bogdan, MD<sup>1</sup>; Paul Tornetta, III, MD<sup>1</sup>; Ross K. Leighton, MD<sup>2</sup>;*

*H. Claude Sagi, MD<sup>3</sup>; Charles C. Nalley, MD<sup>3</sup>; David W. Sanders, MD<sup>4</sup>;*

*Judith A. Siegel, MD<sup>5</sup>; Brian H. Mullis, MD<sup>6</sup>; Thomas B. Bemenderfer, MD<sup>6</sup>;*

*Heather A. Vallier, MD<sup>7</sup>; Alysse Boyd, MA<sup>7</sup>; Andrew H. Schmidt, MD<sup>8</sup>;*

*Jerald R. Westberg, BS<sup>8</sup>; Kenneth A. Egol, MD<sup>9</sup>; Stephen A. Kottmeier, MD<sup>10</sup>;*

*Cory A. Collinge, MD<sup>11</sup>; Robert A. Probe, MD<sup>11</sup>;*

<sup>1</sup>Boston Medical Center, Boston, Massachusetts, USA;

<sup>2</sup>Dalhousie University, Halifax, Nova Scotia, Canada;

<sup>3</sup>Tampa General Hospital, Tampa, Florida, USA;

<sup>4</sup>London Health Sciences Center, London, Ontario, Canada;

<sup>5</sup>University of Massachusetts, Worcester, Massachusetts, USA;

<sup>6</sup>Indiana University-Purdue, Indianapolis, Indiana, USA;

<sup>7</sup>MetroHealth Medical Center, Cleveland, Ohio, USA;

<sup>8</sup>Hennepin County Medical Center, Minneapolis, Minnesota, USA;

<sup>9</sup>NYU Medical Center, New York, New York, USA;

<sup>10</sup>Stony Brook University Health Sciences Center, Stony Brook, New York, USA;

<sup>11</sup>Texas Health Fort Worth, Fort Worth, Texas, USA

11:33 am

Discussion

11:39 am –  
12:45 pm

Lunch

Δ OTA Grant

See pages 97 - 144 for financial disclosure information.

12:45 –  
1:55 pm

**SYMPOSIUM 3:  
ATYPICAL FEMUR FRACTURES**

- (Notes p. ) Moderators: *Joseph Borrelli, Jr., MD*  
*Saam Morshed, MD, PhD*
- 12:45 pm **Did Experimental Evidence Tell Us of the Problems with Long Term Bisphosphonate Use?**  
*Joseph M. Lane, MD*
- 12:55 pm **Making the Observation: From the First Cluster of Events to Quantifying the Risk**  
*Saam Morshed, MD, PhD*
- 1:05 pm **When are Large Trials not Large Enough to Give Us Answers?**  
*Brad A. Petrisor, MD*
- 1:15 pm **Lessons Learned: How Do We Avoid This Type of Problem from Happening Again?**  
*Susan V. Bukata, MD*
- 1:25 pm **Bisphosphonate-Related Femur Fractures: Outcomes of Operative and Nonoperative Management**  
*Kenneth A. Egol, MD*
- 1:35 pm Discussion

1:55 –  
3:01 pm

**PAPER SESSION 3:  
BONE REPAIR**

- Moderators: *Joseph Borrelli, Jr., MD*  
*Andrew H. Schmidt, MD*
- 1:55 pm **Overview**  
*Joseph Borrelli, Jr., MD*
- 2:05 pm **Inhibiting Macrophage Activation During Fracture Repair Improves Fracture Healing in Aged Mice**  
(p. )  
PAPER #10  
*Yan Yiu Yu, PhD; Theodore Miclau III, MD; Ralph S. Marcucio, PhD;*  
*Department of Orthopaedic Surgery, Orthopaedic Trauma Institute,*  
*University of California San Francisco, San Francisco, California, USA*
- 2:11 pm **Δ The Role of the Progressive Ankylosis Protein (Ank) in Bone Fracture Healing**  
(p. )  
PAPER #11  
*Martin Quirno, MD; Scott R. Hadley, MD; Kenneth A. Egol, MD;*  
*Thorsten Kirsch, PhD;*  
*NYU Hospital for Joint Diseases, New York, New York, USA*

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## Basic Science Focus Forum – WEDNESDAY, OCTOBER 3, 2012

2:17 pm **Δ Role of HtrA1 in the Transition From Cartilage to Bone in Fracture Healing**  
(p. )  
PAPER #12 *Marie E. Walcott, MD; John J. Wixted, MD; Monica Thim, BA; David C. Ayers, MD; Paul J. Fanning, PhD; University of Massachusetts Medical School, Worcester, Massachusetts, USA*

2:23 pm **Tracking the Homing of Mesenchymal Stem Cells and Efficacy of Their Healing Potential in a Mouse Fracture Model**  
(p. )  
PAPER #13 *Tina Dreger, MD<sup>1</sup>; J. Tracy Watson, MD<sup>1</sup>; Zijun Zhang, MD, PhD<sup>1</sup>; Walter Akers, DVM, PhD<sup>2</sup>; <sup>1</sup>Saint Louis University School of Medicine, Saint Louis, Missouri, USA; <sup>2</sup>Washington University School of Medicine, Saint Louis, Missouri, USA*

2:29 pm Discussion

2:37 pm **Notch Signaling in Mesenchymal Stem Cells (MSCs) Harvested from Geriatric Mice**  
(p. )  
PAPER #14 *Patricia L. Mutyaba, BS; Hailu Shitaye, PhD; Nicole S. Belkin, MD; Chancellor F. Gray, MD; Derek Dopkin, BS; Jaimo Ahn, MD, PhD; Kurt D. Hankenson, DVM, PhD; University of Pennsylvania, Philadelphia, Pennsylvania, USA*

2:43 pm **BMP-2 mRNA Expression After Endothelial Progenitor Cell Therapy for Fracture Healing**  
(p. )  
PAPER #15 *Ru Li, MD<sup>1,2</sup>; Aaron Nauth, MD<sup>1</sup>; Rajiv Gandhi, MD<sup>2</sup>; Khalid Syed, MD<sup>2</sup>; Emil H. Schemitsch, MD<sup>1</sup>; <sup>1</sup>Department of Surgery, St. Michael's Hospital, University of Toronto, Toronto, Ontario, Canada; <sup>2</sup>Department of Surgery, Toronto Western Hospital, University of Toronto, Toronto, Ontario Canada*

2:49 pm **Δ Cell Viability and Osteogenic Potential of Bone Graft Obtained via Iliac Crest Versus Reamer-Irrigator-Aspirator**  
(p. )  
PAPER #16 *Harmeeth S. Uppal, MD, MS; Blake E. Peterson, BS; Michael Misfeldt, PhD; David Volgas, MD; Yvonne M. Murtha, MD; Gregory J. Della Rocca, MD, PhD, FACS; Theodore J. Choma, MD; James P. Stannard, MD; Brett D. Crist, MD, FACS; University of Missouri, Columbia, Missouri, USA*

2:55 pm Discussion

3:01 pm Break

3:20 –  
4:35 pm

#### SYMPOSIUM 4: INTRAOPERATIVE IMAGING

(Notes p. ) Moderators: *Edward J. Harvey, MD  
Amir M. Matityahu, MD*

3:20 pm **Digital Pre-Operative Planning: Is it Ready for Prime Time?**  
*Christian Krettek, MD*

Δ OTA Grant  
See pages 97 - 144 for financial disclosure information.



## Basic Science Focus Forum – WEDNESDAY, OCTOBER 3, 2012

- 3:30 pm            **Two D vs. 3D Computer Navigation: Does It Make the Technology More Appealing?**  
*David M. Kahler, MD*
- 3:40 pm            **Intraoperative Assessment of Reduction: Does It Make a Difference?**  
*Meir Marmor, MD*
- 3:50 pm            **Intraoperative Radiation Exposure: How Concerned Should We Be?**  
*Eric Meinberg, MD*
- 4:00 pm            **Intraoperative Imaging: What Is New on the Horizon?**  
*Chip Truwit, MD*
- 4:15 pm            Discussion

4:35 –  
5:09 pm

### PAPER SESSION 4: IMAGING-ASSISTED RESEARCH

Moderators: *Edward J. Harvey, MD*  
*Amir M. Matityahu, MD*

- 4:35 pm            **Overview**  
*Amir M. Matityahu, MD*
- 4:45 pm            **Δ Accurate Screw Placement for Displaced Intra-Articular Calcaneus Fractures**  
(p. )  
PAPER #17  
*Jaron P. Sullivan, MD; Phinit Phisitkul, MD; J. Lawrence Marsh, MD;*  
*Jessica Goetz, PhD;*  
*University of Iowa Hospitals and Clinics, Iowa City, Iowa, USA*
- 4:51 pm            **Shifting of the Forearm Bones With Improper Sizing in Radial Head Arthroplasty**  
(p. )  
PAPER #18  
*Winston Elliott, MS<sup>1,2</sup>; Prasad Sawardeker, MD<sup>3</sup>; Check C. Kam, MD<sup>3</sup>;*  
*Elizabeth A. Ouellette, MD, MBA<sup>1</sup>; Loren L. Latta, MD, PhD<sup>2,3</sup>;*  
*<sup>1</sup>Miami International Hand Surgery Services, Miami Beach, Florida, USA;*  
*<sup>2</sup>Max Biedermann Institute for Biomechanics, Miami Beach, Florida, USA;*  
*<sup>3</sup>University of Miami, Department of Orthopaedics, Miami, Florida, USA*
- 4:57 pm            **Tibial Plateau Fracture Depression: Do Locking Plates Support the Entire Lateral Plateau?**  
(p. )  
PAPER #19  
*Stephen A. Sems, MD; William W. Cross, MD; Joseph R. Cass, MD;*  
*Department of Orthopedic Surgery, Mayo Clinic, Rochester, Minnesota, USA*
- 5:03 pm            Discussion
- 5:09 pm            Adjourn

### Basic Science Focus Forum resumes tomorrow:

6:30 am – Continental Breakfast  
7:25 am – Forum Reconvenes

Δ OTA Grant

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## 2012 BASIC SCIENCE FOCUS FORUM THURSDAY, OCTOBER 4, 2012

- 6:30 am **Continental Breakfast**  
(Outside Meeting Event)
- Speaker Ready Room**  
(Convention Center 101 AB)
- 7:25 am **Introduction** (Convention Center 101 AB)  
*Theodore Miclau, III, MD, Program Chair*

7:30 –  
8:35 am

### SYMPOSIUM 5: INSTITUTIONAL UPDATES: STATE OF MUSCULOSKELETAL RESEARCH

- (Notes p. ) Moderators: *Theodore Miclau, III, MD*  
*R Geoff Richards, PhD*
- 7:30 am **NIH/National Institutes of Arthritis, Musculoskeletal, and Skin Diseases  
Intramural Program**  
*Leon J. Nesti, MD*
- 7:45 am **AO Research Institute**  
*R. Geoff Richards, MD*
- 8:00 am **US Army Institute of Surgical Research**  
*Joseph C. Wenke, MD*
- 8:15 am Discussion

8:35 –  
9:19 am

### PAPER SESSION 5: MUSCULOSKELETAL INFECTION

- Moderators: *Theodore Miclau, III, MD*  
*R. Geoff Richards, PhD*
- 8:35 am **Overview**  
*R. Geoff Richards, PhD*

See pages 97 - 144 for financial disclosure information.

## Basic Science Focus Forum – THURSDAY, OCTOBER 4, 2012

- 8:45 am (p. ) PAPER #20 **Electrospun Polyvinyl Alcohol (PVA)/Cyclodextrin/Tobramycin Nanofibrous Scaffold for Bone Infection**  
David C. Markel, MD<sup>1</sup>; Weiping Ren, MD, PhD<sup>1,2</sup>;  
<sup>1</sup>Detroit Medical Center/Providence Hospital Orthopaedic Residency Program, Detroit, Michigan, USA;  
<sup>2</sup>Department of Biomedical Engineering, Wayne State University, Detroit, Michigan, USA
- 8:51 am (p. ) PAPER #21 **Nanoparticle-Antimicrobial Complexes for the Treatment of Intracellular *Staphylococcus aureus* Osteoblast Infections**  
David I. Devore, PhD; Crystal Archer; Asa Vaughan; Maria Cormier; Krista L. Niece; US Army Institute of Surgical Research, Fort Sam Houston, Texas, USA
- 8:57 am Discussion
- 9:02 am (p. ) PAPER #22 **•Anti-Infection Trauma Devices With Drug-Releasing and Nonfouling Surface Modification**  
Hao Wang, MD; Karen D. Schultz, MD; Koby J. Elias, BS; Christopher Loose, PhD; Semprus BioSciences, Cambridge, Massachusetts, USA
- 9:08 am (p. ) PAPER #23 **A Novel SPCP Scaffold Composite for Erythromycin Release in a Mouse Infection Model**  
David C. Markel, MD<sup>1</sup>; Nancy M. Jackson, PhD<sup>1</sup>; Jeffery C. Flynn, MD<sup>1</sup>; Weiping Ren, MD, PhD<sup>1,2</sup>;  
<sup>1</sup>Department of Orthopaedics, Providence Hospital and Medical Centers, Southfield, Michigan, USA;  
<sup>2</sup>Wayne State University Biomedical Engineering, Detroit, Michigan, USA
- 9:14 am Discussion
- 9:19 am Break

9:35 –  
10:45 am**SYMPOSIUM 6:  
CYCLE OF INNOVATION**

- (Notes p. ) Moderators: Mohit Bhandari, MD, PhD, FRCSC  
Saam Morshed, MD, PhD
- 9:35 am **The Cycle of Innovation: Is There an Ideal Approach?**  
Mohit Bhandari, MD, PhD, FRCSC
- 9:45 am **Taking Early Innovation into the Clinical Arena**  
Paul Tornetta, III, MD
- 9:55 am **Taking Promising Innovation into Clinical Practice: What are the Studies We Should be Doing?**  
Saam Morshed, MD, PhD

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**Basic Science Focus Forum – THURSDAY, OCTOBER 4, 2012**

10:10 am **Getting through the FDA Approval Process**  
*Thomas A. Russell, MD*

10:25 am Discussion

10:45 –  
11:19 am

**PAPER SESSION 6:  
CLINICAL RESEARCH**

Moderators: *Mohit Bhandari, MD, PhD, FRCSC*  
*Saam Morshed, MD, PhD*

10:45 am **Overview**  
*Saam Morshed, MD, PhD*

10:55 am **Research in Orthopaedic Trauma: Has Anything Changed Since the**  
(p. ) **Introduction of Levels of Evidence?**  
PAPER #24 *Brian P. Cunningham, MD<sup>1</sup>; Gilbert R. Ortega, MD, MPH<sup>2</sup>;*  
*Ryan McLemore, PhD<sup>1</sup>; Alexander C. McLaren, MD<sup>1</sup>;*  
*<sup>1</sup>Banner Orthopaedic Residency, Phoenix, Arizona, USA;*  
*<sup>2</sup>Sonoran Orthopaedic Trauma Surgeons, Scottsdale, Arizona, USA*

11:01 am **The Difficulty in Performing a High-Quality Randomized Trial for the**  
(p. ) **Distal Radius: Are These Insurmountable Challenges?**  
PAPER #25 *Paul Tornetta, III, MD; Tarek Sibai, MD; Hope Carlisle, RN;*  
*Boston University Medical Center, Boston, Massachusetts, USA*

11:07 am **Journal Impact Factor: Does It Reflect the Impact of Clinical Research in**  
(p. ) **Trauma and Orthopaedic Surgery?**  
PAPER #26 *Preetham Kodumuri, MBBS, MRCS; Jonathan Holley;*  
*Benjamin Ollivere, MD, FRCS; Christopher G. Moran, MD, FRCS;*  
*Nottingham University Hospitals, Nottingham, United Kingdom*

11:13 am Discussion

11:19 am Basic Science Focus Forum Adjourns

**28TH ANNUAL MEETING BEGINS AT 1:00 PM**



THURSDAY, OCTOBER 4, 2012

SCHEDULE

2:50 pm

Break

Visit Scientific Posters & Technical Exhibits (*Convention Center Hall C*)

## SCIENTIFIC SESSION I HIP FRACTURES

3:20 –  
4:52 pm

Moderators - John T. Ruth, MD & J. Tracy Watson, MD

3:20 pm

(p. )

PAPER #27

### **More Reoperations After Intramedullary Nailing Compared With Sliding Hip Screws in the Treatment of AO/OTA Type A1 Trochanteric Fractures: Results After 7643 Operations Reported to the Norwegian Hip Fracture Register**

*Kjell Matre, MD; Leif Ivar Havelin, MD, PhD; Jan Erik Gjertsen, Tarjei Vinje; Birgitte Espehaug; Jonas M. Fevang, MD; Orthopaedic Department, Haukeland University Hospital, Bergen, Norway*

3:26 pm

(p. )

PAPER #28

### **A Comparison of Cemented and Uncemented Bipolar Hemiarthroplasty Complications in the Early Postoperative Period**

*Ross K. Leighton, MD, FRCSC, FACS<sup>1,2</sup>; Uwe Dahn, MD<sup>1</sup>; Kelly Trask, BEng, MSc, CCRP<sup>2</sup>; <sup>1</sup>Dalhousie University, Halifax, Nova Scotia, Canada; <sup>2</sup>Capital District Health Authority, Halifax, Nova Scotia, Canada*

3:32 pm

(p. )

PAPER #29

### **Internal Fixation Versus Cemented Unipolar Hemiarthroplasty for Displaced Femoral Neck Fractures in Elderly Patients With Severe Cognitive Dysfunction: A Randomized, Controlled Trial**

*Carl-Johan Hedbeck, MD; Christian Inngul; Richard Blomfeldt, MD; Hans Törnkvist, MD, PhD; Sari Ponzer, MD, PhD; Anders G. Enocson, MD, PhD; Karolinska Institutet, Department of Clinical Science and Education, Orthopaedic Unit, Stockholm Söder Hospital, Stockholm, Sweden*

3:38 pm

Discussion

3:43 pm

(p. )

PAPER #30

### **Treatment of Pertrochanteric Fractures (AO/OTA 31-A1 and A2): Long Versus Short Cephalomedullary Nailing**

*Kaan S. Irgit, MD; Zhiyong Hou, MD; Thomas R. Bowen, MD; Michelle E. Matzko, PhD; Cassondra M. Andreychik, BA; Daniel S. Horwitz, MD; Wade R. Smith, MD; Geisinger Medical Center, Department of Orthopaedic Surgery, Danville, Pennsylvania USA*

3:49 pm

(p. )

PAPER #31

### **Short Versus Long Intramedullary Nails for Intertrochanteric Femur Fractures**

*Kelly Carlberg, MD; Christopher Boone, MD; Denise Koueiter, MS; Kevin Baker, PhD; Jason Sadowski, MD; Patrick Wiater, MD; Gregory Nowinski, MD; Kevin Grant, MD; Department of Orthopaedic Surgery, Beaumont Health System, Royal Oak, Michigan, USA*

See pages 97 - 144 for financial disclosure information.

3:55 pm  
(p. )  
PAPER #32

**Locked Plating of Proximal Femur Fractures: Outcomes and Predictors of Failure**

**Robert A. Hymes, MD<sup>1</sup>**; Kelly G. Kilcoyne, MD<sup>2</sup>; Tyler G. Marks, MD<sup>3</sup>; James S. Melvin, MD<sup>4</sup>; Scott Yang, MD<sup>5</sup>; Jennifer H. Wood, MD<sup>6</sup>; Matt L. Graves, MD<sup>3</sup>; David S. Weiss, MD<sup>5</sup>; Michael C. Tucker, MD<sup>6</sup>; Lisa K. Cannada, MD<sup>7</sup>; Elyse S. Brinkmann<sup>7</sup>; J. Tracy Watson, MD<sup>7</sup>;  
<sup>1</sup>Inova Fairfax Hospital, Fairfax, Virginia, USA;  
<sup>2</sup>Walter Reed Medical Center, Bethesda, Maryland, USA;  
<sup>3</sup>University of Mississippi, Jackson, Mississippi, USA;  
<sup>4</sup>Carolinas Medical Center, Charlotte, North Carolina, USA;  
<sup>5</sup>University of Virginia, Charlottesville, Virginia, USA;  
<sup>6</sup>Palmetto Health, Columbia, South Carolina, USA;  
<sup>7</sup>Saint Louis University, Saint Louis, Missouri

4:01 pm

Discussion

4:06 pm  
(p. )  
PAPER #33

**Displaced Femoral Neck Fractures in Patients <60 Years of Age**

**Stephen T. Gardner, MD**; Michael J. Weaver, MD; Seth A. Jerabek, MD; Mark S. Vrahas, MD; Paul T. Appleton, MD; Mitchel B. Harris, MD; Brigham and Women's Hospital, Boston, Massachusetts, USA; Massachusetts General Hospital, Boston, Massachusetts, USA; Beth Israel Deaconess Hospital, Boston, Massachusetts, USA

4:12 pm  
(p. )  
PAPER #34

**Outcomes After Treatment of Femoral Neck Fractures in Young Patients**

**Andrew N. Pollak, MD<sup>1</sup>**; Emily Hui, MPH<sup>1</sup>; Renan C. Castillo, MS<sup>1</sup>; Bingfang Zeng, MD<sup>2</sup>; Dong Wang, MD<sup>2</sup>; Baotong Ma, DO<sup>2</sup>;  
<sup>1</sup>R Adams Cowley Shock Trauma Center, Baltimore, Maryland, USA;  
<sup>2</sup>The Shanghai Sixth People's Hospital, Shanghai Kiao Tong University, Shanghai, China

4:18 pm  
(p. )  
PAPER #35

**Diagnosis of Femoral Neck Fractures Present With Femoral Shaft Fractures: Do We Need Intra-Operative Radiographs?**

**Simon L. Amsdell, MD**; Catherine A. Humphrey, MD; Jonathan M. Gross, MD; John P. Ketz, MD, John T. Gorczyca, MD; Holman Chan, MD; University of Rochester Medical Center, Rochester, New York, USA

4:24 pm

Discussion

4:29 pm  
(p. )  
PAPER #36

**Delay to Surgery in Hip Fracture Patients: Effect on Mortality, Length of Stay, and Postoperative Morbidity**

**Reshid Berber, MBBS**; Christopher G. Moran, MD, FRCS; Queen's Medical Centre, Nottingham University Hospitals, Nottingham, United Kingdom

4:35 pm  
(p. )  
PAPER #37

**Postoperative Urinary Tract Infection Results in Higher Rates of Deep Infection in Patients With Proximal Femoral Fractures**

**Benjamin J. Ollivere, FRCS, MBBS, MD**; Thomas Kurien, MBBS; Claire Morris, MA; Daren P. Forward, FRCS; Christopher G. Moran, MD, FRCS; Queens Medical Centre, Nottingham, United Kingdom

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**THURSDAY, OCTOBER 4, 2012**

**SCHEDULE**

4:41 pm **No Effects of Blood Transfusion on Survival After Hip Fracture Surgery**  
(p. )  
PAPER #38  
*S.J.M. Smeets, MD; Martijn Poeze, MD, PhD; Jan Verbruggen, MD, PhD;*  
*Maastricht University Medical Center, Maastricht, The Netherlands*

4:47 pm Discussion

4:52 –  
5:22 pm  
(Notes p. )

**PRESIDENT'S  
MESSAGE**

*(General Session Room - Ballroom AB)*

*Robert A. Probe, MD*

**“The Changing Value Proposition of the  
Orthopaedic Traumatologist”**

*Introduced by his fellowship mentor  
Ronald W. Lindsey, MD*



5:25 pm **OTA BUSINESS MEETING**  
OTA Members Only *(General Session Room - Ballroom AB)*

6:30 pm

**WELCOME  
RECEPTION**

Join the OTA for cocktails and a generous assortment of hors d'oeuvres at Windows on Minnesota. Windows is located on the 50th floor of the Marquette hotel, a short walk from the Convention Center.



*Windows on Minnesota*

See pages 97 - 144 for financial disclosure information.



# 2012 OTA ANNUAL MEETING

## FRIDAY, OCTOBER 5, 2012

- 6:15 am            **Continental Breakfast**  
*(Available at Breakout Sessions)*
- Attendee Registration**  
*(Convention Center Foyer Ballroom AB)*
- 6:30 am            **Speaker Ready Room**  
*(Convention Center 202 AB)*
- 7:00 am            **Scientific Posters** (Technical Exhibits Open at 9:00 am)  
*(Convention Center Hall C)*
- Continental Breakfast**  
*(Convention Center Hall C)*
- 6:30 - 7:45 am    **Concurrent Breakout Sessions**  
(Notes p.    )
  - a) Skills Labs
  - b) Case Presentations

6:30 – 7:45 am	SKILLS LABS	Tickets Required
	<b>Joint Spanning External Fixator for Temporizing Articular Fractures (#F1)</b> Moderator: <i>Cory A. Collinge, MD</i> Faculty: <i>Michael T. Archdeacon, MD; Bradley R. Merk, MD; Greg M. Osgood, MD; Robert A. Probe, MD; David Seligson, MD and Nirmal C. Tejwani, MD</i>	(M100 EF)
	<b>ORIF Distal Femur Fractures (#F2)</b> Moderator: <i>Mark C. Reilly, MD</i> Faculty: <i>Derek J. Donegan, MD; David F. Hubbard, MD and Roger G. Wilber, MD</i>	(M100 AB)

6:30 – 7:45 am	CASE PRESENTATIONS	No Tickets Required
	<b>Coding Update with Case-Based Learning</b> Moderator: <i>William R Creevy, MD</i> Faculty: <i>J. Scott Broderick, MD and M. Bradford Henley, MD</i>	(200 ABC)
	<b>Pelvis and Acetabulum</b> Moderator: <i>Paul Tornetta, III, MD</i> Faculty: <i>Thomas F. Higgins, MD; Robert F. Ostrum, MD and Philip R. Wolinsky, MD</i>	(Ballroom AB)

*continued next page*

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FRIDAY, OCTOBER 5, 2012

SCHEDULE

6:30 –  
7:45 am

**CASE PRESENTATIONS, continued**

**Pediatric Femur Fractures**

(200 DE)

Moderator: *Enes Kanlic, MD, PhD*

Faculty: *Amr A. Abdelgawad, MD; J. Eric Gordon, MD and Marc F. Swiontkowski, MD*

**Proximal Humerus Fractures**

(200 FG)

Moderator: *Utku Kandemir, MD*

Faculty: *Michael J. Gardner, MD; John T. Gorczyca, MD;  
Michael D. McKee, MD and Milan K. Sen, MD*

8:00 –  
9:30 am

**SYMPOSIUM II:  
AUTOMOTIVE MEDICINE AND ORTHOPAEDIC TRAUMA**

(Notes p. ) Moderator: *James A. Goulet, MD*

(General Session Room-Ballroom AB)

Faculty:

**Add Faculty &  
Symposium  
Details**

9:30 am

Break

Visit Scientific Posters & Technical Exhibits (*Convention Center Hall C*)

See pages 97 - 144 for financial disclosure information.

- 10:00 - 11:15 am **Concurrent Sessions (Mini Symposia and Scientific Session run concurrently.)**  
 a) Mini Symposia  
 b) Scientific Session II: Foot and Ankle Papers (Ballroom AB)

10:00 – 11:15 am	MINI SYMPOSIA	No Tickets Required
	<b>Workers Compensation: An Orthopaedic Trauma Perspective</b>	(200 ABC)
	Moderator: <i>Hassan R. Mir, MD</i>	
	Faculty: <i>Lisa K. Cannada, MD; Cory A. Collinge, MD; A. Alex Jahangir, MD</i> <i>William T. Obremskey, MD, MPH and Manish K. Sethi, MD</i>	
	<b>How to Establish and Run a Fragility Fracture Program (Own the Bone)</b>	(200 DE)
	Moderator: <i>James A. Goulet, MD</i>	
	Faculty: <i>Clifford B. Jones, MD; Kyle J. Jeray, MD and Marc F. Swiontkowski, MD</i>	

**SCIENTIFIC SESSION II  
FOOT and ANKLE**

10:00 –  
11:15 am Moderators - Pierre Guy, MD, MBA & David W. Sanders, MD

10:00 am (p. ) PAPER #39 **Gravity Stress Radiographs: Does a Positive Radiograph Mean an Unstable Ankle?**  
*Kate Ella Bugler; George Smith, FRCS; Timothy O. White, MD, FRCS; Orthopaedic Trauma Unit, Royal Infirmary Edinburgh, Edinburgh, Scotland, United Kingdom*

10:06 am (p. ) PAPER #40 **Early Routine Weight Bearing Is Safe in Patients With Ankle Fractures**  
*Kate Ella Bugler; Timothy O. White, MD, FRCS; Orthopaedic Trauma Unit, Royal Infirmary Edinburgh, Edinburgh, Scotland, United Kingdom*

10:12 am (p. ) PAPER #41 **Does the Fibula Need to Be Fixed in Complex Pilon Fractures?**  
*John C. Kurylo, MD; Neil Datta, Kendra N. Iskander, MD, MPH; Paul Tornetta, III, MD; Boston University Medical Center, Boston, Massachusetts, USA*

10:18 am Discussion

10:23 am (p. ) PAPER #42 **Operative Treatment of Displaced Intra-Articular Calcaneal Fractures: Long-Term (10-20 Years) Results in 108 Fractures Using a Prognostic CT Classification**  
*Roy Sanders, MD; Zachary Vaupel, MD; Florida Orthopaedic Institute, Tampa, Florida, USA*

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FRIDAY, OCTOBER 5, 2012

SCHEDULE

10:29 am (p. ) PAPER #43  
**A New Look at the Hawkins Classification for Talar Neck Fractures: Which Features of Injury and Treatment Are Predictive of Osteonecrosis?**  
*Stephen G. Reichard, MD; Heather A. Vallier, MD; Alysse J. Boyd, MA; Timothy A. Moore, MD; MetroHealth Medical Center, Cleveland, Ohio, USA*

10:35 am (p. ) PAPER #44  
**A Prospective, Randomized Controlled Trial of the Acumed Fibular Nail Versus Standard Open Reduction and Internal Fixation for Fixation of Ankle Fractures**  
*Timothy O. White, MD, FRCS; Kate E. Bugler; Paul T. Appleton, MD; Margaret M. McQueen, MD; Charles M. Court-Brown, MD; Edinburgh, Scotland, United Kingdom*

10:41 am Discussion

10:46 am (p. ) PAPER #45  
**Δ Can We Tell If the Syndesmosis is Reduced Using Fluoroscopy?**  
*Paul Tornetta III, MD; Scott Koenig, MD; Gabriel Merlin; Yelena Bogdan, MD; Boston University Medical Center, Boston, Massachusetts, USA*

10:52 am (p. ) PAPER #46  
**Anatomic Reduction of the Syndesmosis: What Values to Trust?**  
*Jonah Hebert-Davies, MD<sup>1,2</sup>; Marie-Lyne Nault, MD<sup>1,2</sup>; George Yves Laflamme, MD<sup>1</sup>; Stephane Leduc, MD<sup>1</sup>; <sup>1</sup>Hopital du Sacre-Coeur, Montreal, Quebec, Canada <sup>2</sup>University of Montreal, Montreal Quebec, Canada*

10:58 am (p. ) PAPER #47  
**The Effect of Syndesmosis Screw Removal on the Reduction of the Distal Tibiofibular Joint**  
*CPT Daniel J. Song, MD; CPT Joseph T. Lanzi, MD; MAJ Adam T. Groth, MD; MAJ Matthew Drake, MD; LTC Joseph R. Orchowski, MD; COL Kenneth K. Lindell, MD; Tripler Army Medical Center, Honolulu, Hawaii, USA*

11:04 am (p. ) PAPER #48  
**A Comparison of Weight-Bearing Protocols and Outcomes for Syndesmotic Ankle Fixation: 6 Weeks Versus 12 Weeks**  
*Jeffrey E. McAlister, DPM; Jeff E. Schulman, MD; Noah Oliver, DPM; A. Stephen Malekzadeh, MD; Cary A. Schwartzbach, MD; Matthew S. Levine, MD; Daniel Dziadosz, MD; Robert Hymes, MD; Orthopedic Trauma Program, INOVA Fairfax Hospital, Falls Church, Virginia, USA*

11:10 am Discussion

11:15 am (Notes p. )



The OTA is pleased to share a live broadcast from Italy (OTA's 2011 Guest Nation), recognizing the Italian Society of Orthopaedics and Traumatology Hospitals (OTODI) best poster awards. The OTODI award winners will be sponsored by OTODI to attend the OTA's 2013 Annual Meeting.

<i>Robert A. Probe, MD</i>	<i>Francesco Falez, MD</i>	<i>Francesco Biggi, MD</i>
<i>OTA President</i>	<i>OTODI President</i>	<i>OTODI Past President</i>

The live broadcast will also include the following periprosthetic talk from OTA's general session to the OTODI Conference.

**Periprosthetic Fracture Treatment: An Update (When and How to Fix the Fracture vs Implant Revision) on Hip and Knee** –George J. Haidukewych, MD

See pages 97 - 144 for financial disclosure information.

11:30 am –  
12:00 pm  
(Notes p. )

**JOHN BORDER MEMORIAL LECTURE**

*(General Session Room-Ballroom AB)*

**Orthopaedic Trauma – My Perspective”**

**James F. Kellam, MD, FRCS(C), FACS**  
*Vice Chairman, Department of Orthopaedic Surgery,  
Director of the Orthopaedic Trauma Program,  
Carolinas Medical Center,  
Charlotte, North Carolina, USA*



Introduction: *Stephen H. Sims, MD*

12:00 pm –  
1:00 pm

Lunch  
Visit Scientific Posters & Technical Exhibits *(Convention Center Hall C)*

12:00 pm –  
1:00 pm

**Guided Poster Tours & Lunch** *(tickets required)*


**Pelvis and Acetabulum** (#P1)

*Paul Tornetta, III, MD*

**Lower Extremity** (#P2)

*Roy Sanders, MD*

12:00 pm –  
1:00 pm

 **New Member Luncheon**  
*(tickets required)*  
*(208 A-D)*

12:00 –  
1:00 pm

**Kathy Cramer, MD Memorial  
Women in Orthopaedic Trauma  
Luncheon** *(tickets required)*  
*(101 F)*

Co-Chairs: *Jacqueline J. Krumrey, MD*  
*Laura S. Phieffer, MD*



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**FRIDAY, OCTOBER 5, 2012**

1:00 - 2:30 pm      **Concurrent Sessions**  
*(Skills Labs, Mini Symposia and Scientific Session run concurrently.)*  
 a) Skills Labs  
 b) Mini Symposia  
 c) Scientific Session III: Basic Science Papers (*Ballroom AB*)

1:00 – 2:30 pm	<b>SKILLS LABS</b>	<i>Tickets Required</i>
<b>ORIF Distal Radius Fractures (#F3)</b> (M100 CD)		
Moderator: <i>Erik N. Kubiak, MD</i>		
Faculty: <i>Greg Altman, MD; Eric W. Fulkerson, MD; Michael D. McKee, MD; Amer J. Mirza, MD and Milak K. Sen, MD</i>		
<b>ORIF Distal Tibia and Fibula Fractures (#F4)</b> (1011-J)		
Moderator: <i>J. Tracy Watson, MD</i>		
Faculty: <i>Mark J. Anders, MD; David E. Karges, DO; Frank A. Liporace, MD; Steven J. Morgan, MD and Anthony S. Rhorer, MD</i>		
<b>SIGN – Surgical Implant Generation Network (#F5)</b> (101 CD)		
Moderator: <i>Lewis G. Zirkle, Jr., MD</i>		
Faculty: <i>Duong Bunn, MD; Luigi A. Sabal, MD; Robert S. Schultz, MD; Faseeh Shahab, MD; Prof Shahab-uddin, MD; Carla S. Smith, MD and Frederic B. Wilson, Jr, MD</i>		

1:00 – 2:30 pm	<b>MINI SYMPOSIA</b>	<i>No Tickets Required</i>
<b>US Policy and Healthcare Reform: An Update</b> (200 ABC)		
Moderator: <i>Manish K. Sethi, MD</i>		
Faculty: <i>A. Alex Jahangir, MD; Hassan R. Mir, MD and Steven A. Olson, MD</i>		
<b>Periprosthetic Fractures</b> (200 DE)		
Moderator: <i>Michael D. McKee, MD</i>		
Faculty: <i>George J. Haidukewych, MD; Hans J. Kreder, MD; William M. Ricci, MD and Emil H. Schemitsch, MD</i>		
<b>Infections with Resistant Bacteria – Are They Winning the Battle?</b> (200 FG)		
Moderator: <i>Stephen L. Kates, MD</i>		
Faculty: <i>Volker Alt, MD; Edward Schwarz, PhD and Michael Suk, MD, JD, MPH</i>		

See pages 97 - 144 for financial disclosure information.

## SCIENTIFIC SESSION III BASIC SCIENCE

1:00 –  
2:03 pm

Moderators - Theodore Miclau, III, MD & Edward J. Harvey, MD

SCHEDULE

- 1:00 pm  
(p. )  
PAPER #49
- Intra-Articular Inhibition of Interleukin-1 Prevents Posttraumatic Arthritis Following Articular Fracture in the Mouse Knee**  
*Daniel S. Mangiapani, MD; Evan M. Zeitler, BA; Bridgett D. Furman, BS; Janet L. Huebner, MS; Virginia B. Kraus, MD, PhD; Farshid Guilak, PhD; Steven A. Olson, MD;*  
*Duke University Medical Center, Durham, North Carolina, USA*
- 1:06 pm  
(p. )  
PAPER #50
- Δ The Severity of Microvascular Dysfunction Due to Compartment Syndrome Is Diminished by the Systemic Application of CO-Releasing Molecules (CORM-3)**  
*Abdel-Rahman Lawendy, MD; Relka Bihari, MSc; David W. Sanders, MD, PhD; Gediminas Cepinskas, PhD;*  
*London Health Sciences Centre, London, Ontario, Canada*
- 1:12 pm  
(p. )  
PAPER #51
- Can Glucose Levels Diagnose Compartment Syndrome?**  
*Christopher J. Doro, MD<sup>1</sup>; Thomas J. Sitzman, MD<sup>2</sup>; Robert V. O'Toole, MD<sup>3</sup>;*  
*<sup>1</sup>Department of Orthopaedics, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin, USA;*  
*<sup>2</sup>Division of Plastic Surgery, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin, USA;*  
*<sup>3</sup>R Adams Cowley Shock Trauma Center, Department of Orthopaedics, University of Maryland School of Medicine, Baltimore, Maryland, USA*
- 1:18 pm
- Discussion
- 1:23 pm  
(p. )  
PAPER #52
- Local Bismuth Thiols Potentiate Antibiotics and Reduce Infection in a Contaminated Open Fracture Model**  
*Jowan Penn-Barwell, MRCS<sup>1</sup>; Brett H.J. Baker, MSc, DC<sup>2</sup>; Joseph C. Wenke, PhD<sup>3</sup>;*  
*<sup>1</sup>Royal Centre for Defence Medicine, Birmingham, United Kingdom;*  
*<sup>2</sup>Microbion Corporation, Bozeman, Montana, USA;*  
*<sup>3</sup>U.S. Army Institute of Surgical Research, Fort Sam Houston, Texas, USA*
- 1:29 pm  
(p. )  
PAPER #53
- Eradication of Wound Contamination Is Improved By Synergistic Effects of Local and Systemic Antibiotic Delivery**  
*Ben C.C. Rand, MRCS<sup>1,2</sup>; Jowan G. Penn-Barwell, MRCS<sup>1,2</sup>;*  
*Joseph C. Wenke, PhD<sup>1</sup>;*  
*<sup>1</sup>U.S. Army Institute of Surgical Research, Fort Sam Houston, Texas, USA;*  
*<sup>2</sup>Academic Department of Military Surgery and Trauma, Royal Centre for Defense Medicine, Birmingham, United Kingdom*

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**FRIDAY, OCTOBER 5, 2012**

**SCHEDULE**

- 1:35 pm  
(p. )  
PAPER #54
- Chitosan: An Effective NPWT-Compatible Local Antibiotic Delivery Device**  
*Ben C.C. Rand, MRCS<sup>1,2</sup>; Scott P. Noel, PhD<sup>3</sup>; Joseph C. Wenke, PhD<sup>1</sup>;*  
*<sup>1</sup>U.S. Army Institute of Surgical Research, Fort Sam Houston, Texas, USA*  
*<sup>2</sup>Academic Department of Military Surgery and Trauma,*  
*Royal Centre for Defense Medicine, Birmingham, United Kingdom;*  
*<sup>3</sup>Bionova Medical, Memphis, Tennessee, USA*
- 1:41 pm
- Discussion
- 1:46 pm  
(p. )  
PAPER #55
- Comparison of Standard Iliosacral Screw Fixation to Transsacral Locked Screw Fixation in a Type C Zone II Pelvic Fracture Model With Residual Fracture Site Separation**  
*Sean A. Tabaie, MD; Gary Bledsoe, PhD; Berton R. Moed, MD;*  
*Saint Louis University School of Medicine, Saint Louis, Missouri, USA*
- 1:52 pm  
(p. )  
PAPER #56
- Short Segment Fixation of an L1 Compression Fracture – Four Versus Six Screws**  
*Seth K. Williams, MD<sup>1</sup>; Robert P. Norton, MD<sup>1</sup>; Edward L. Milne, BSc<sup>2</sup>;*  
*David N. Kaimrajh, MS<sup>2</sup>; Frank Eismont, MD<sup>1</sup>; Loren L. Latta, MD, PhD<sup>1,2</sup>;*  
*<sup>1</sup>Department of Orthopaedics, University of Miami, Miami, Florida, USA;*  
*<sup>2</sup>Max Biedermann Institute for Biomechanics, Miami Beach, Florida, USA*
- 1:58 pm
- Discussion
- 2:30 pm
- Break  
Visit Scientific Posters & Technical Exhibits (Convention Center Hall C)
- 3:00 - 4:30 pm
- Concurrent Sessions (Mini Symposia and Scientific Session run concurrently.)**  
a) Mini Symposia  
b) Scientific Session IV: Pelvis & Acetabulum Papers (Ballroom AB)

**3:00 –  
4:30 pm**

**MINI SYMPOSIA**

*No Tickets Required*

**Plateaus and Pylons: The Posterior Perspective**

(200 ABC)

Moderator: *Stephen A. Kottmeier, MD*

Faculty: *Clifford B. Jones, MD; Paul Tornetta, III, MD and J. Tracy Watson, MD*

**Tools and Tips for Maximizing Physician Assistant Utilization**

(200 DE)

*Tricia Marriott, PA-C, MPAS, DFAAPA,*

*Interim Vice President of Constituent Organization Development;*

*Director Reimbursement Advocacy; American Academy of Physician Assistants*

Faculty: *Dennis Gregory, PA; Debra Sietsema, PhD, RN and Keith Zurmehly, PA*

**Compensation Formulas: What Works and What Doesn't**

(200 FG)

Moderator: *William R. Creevy, MD*

Faculty: *Timothy J. Bray, MD; M. Bradford Henley, MD and Roy Sanders, MD*

See pages 97 - 144 for financial disclosure information.



## SCIENTIFIC SESSION IV PELVIS and ACETABULUM

3:00 –  
4:30 pm

Moderators - James A. Goulet, MD & H. Claude Sagi, MD

SCHEDULE

- 3:00 pm  
(p. )  
PAPER #57
- Functional Outcomes After Nonoperative Treatment of Lateral Compression Type 1 (LC-1) Pelvic Ring Injuries With Complete Sacral Fractures**  
*Greg Gaski, MD; Robert V. O'Toole, MD; Renan Castillo, MS; Gerard P. Slobogean, MD; Theodore T. Manson, MD; R Adams Cowley Shock Trauma Center, Baltimore, Maryland, USA*
- 3:06 pm  
(p. )  
PAPER #58
- Core Muscle Size and Mortality Following Nonoperative Management of Pelvic Fractures**  
*William D. Scheidler, BS; Shaun P. Patel, BS; Sven A. Holcombe, BS<sup>2</sup>; Stewart C. Wang, MD, PhD; James A. Goulet, MD; University of Michigan, Ann Arbor, Michigan, USA*
- 3:12 pm
- Discussion
- 3:17 pm  
(p. )  
PAPER #59
- Transiliac-Transsacral Screw Fixation in C-Type Pelvic Ring Injuries Reduces Postoperative Failure**  
*Gregory Y. Blaisdell, MD<sup>1</sup>; James C. Krieg, MD<sup>2</sup>; Milton L. Chip Routh Jr, MD<sup>2</sup>; <sup>1</sup>University of Washington Department of Orthopaedics and Sports Medicine, Seattle, Washington, USA; <sup>2</sup>Harborview Medical Center, Seattle, Washington, USA*
- 3:23 pm  
(p. )  
PAPER #60
- Transiliac-Transsacral Screw Safe Zone Diameter in 1091 Sacrums**  
*John J. Lee, MD; Alex Martusiewicz, MD; James A. Goulet, MD; University of Michigan, Department of Orthopedic Surgery, Ann Arbor, Michigan, USA*
- 3:29 pm
- Discussion
- 3:34 pm  
(p. )  
PAPER #61
- Is Closed Reduction and Percutaneous Fixation of Type 3 Posterior Ring Injuries as Accurate as Open Reduction and Internal Fixation?**  
*Adam Lindsay, MD<sup>1</sup>; Paul Tornetta, III, MD<sup>1</sup>; Anma Diwan, MD<sup>2</sup>; David C. Templeman, MD<sup>2</sup>; <sup>1</sup>Boston University Medical Center, Boston, Massachusetts, USA; <sup>2</sup>Hennepin County Medical Center, Minneapolis, Minnesota, USA*
- 3:40 pm  
(p. )  
PAPER #62
- Displaced Sacral Fractures: Do Long-Term Radiologic Findings Correlate to Neurologic Deficits and Pain?**  
*Aron Adelved, MD<sup>1,5</sup>; Anna Tötterman, MD, PhD<sup>2</sup>; Thomas Glott, MD<sup>3</sup>; Johan C. Hellund, MD, PhD<sup>4</sup>; Jan Erik Madsen, MD, PhD<sup>5</sup>; Olav Røise, MD, PhD<sup>5</sup>; <sup>1</sup>Orthopaedic Department, Akershus University Hospital, Akershus, Norway; <sup>2</sup>Orthopaedic Department, Karolinska University Hospital, Stockholm, Sweden; <sup>3</sup>Department for Spinal Cord Injuries, Sunnaas Hospital, Nesodden, Norway; <sup>4</sup>Radiologic Department, Oslo University Hospital, Oslo, Norway; <sup>5</sup>Orthopaedic Department, Oslo University Hospital, Oslo, Norway*

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FRIDAY, OCTOBER 5, 2012

SCHEDULE

- 3:46 pm Discussion
- 3:51 pm  
(p. )  
PAPER #63
- Appropriateness of Angiography and Embolization in the Management of High-Energy Pelvic Ring Injuries**  
*Sean M. Griffin, MD; Kenneth J. Nelson, MD; Bryan J. Loeffler, MD; Brian P. Scannell, MD; Michael J. Bosse, MD; James F. Kellam, MD; Stephen H. Sins, MD; Ronald F. Sing, DO; Eric A. Wang, MD; Carolinas Medical Center, Charlotte, North Carolina, USA*
- 3:57 pm  
(p. )  
PAPER #64
- Predictors of Functional Outcome in Operatively Treated Pelvic Ring Fractures**  
*Patrick D.G. Henry, MD, FRCS(C)<sup>1</sup>; Richard J. Jenkinson, MD, FRCS(C)<sup>2</sup>; Sebastian Rodriguez-Elizalde, MD, FRCS(C)<sup>2</sup>; David J.G. Stephen, MD, FRCS(C)<sup>2</sup>; Hans J. Kreder, MD, FRCS(C)<sup>2</sup>;*  
<sup>1</sup>Division of Orthopaedics, Department of Surgery, St. Michael's Hospital, University of Toronto, Toronto Ontario, Canada;  
<sup>2</sup>Division of Orthopaedics, Department of Surgery, Sunnybrook Health Sciences, University of Toronto, Toronto, Ontario, Canada
- 4:03 pm Discussion
- 4:08 pm  
(p. )  
PAPER #65
- Incidence of Posterior Wall Nonunion and Efficacy of Indomethacin Prophylaxis for Heterotopic Ossification After Operative Fixation of Acetabular Fractures: A Randomized Controlled Trial**  
*Charles J. Jordan, MD; Rafael Serrano-Riera, MD; H. Claude Sagi, MD; Orthopaedic Trauma Service, Florida Orthopaedic Institute, Tampa, Florida, USA*
- 4:14 pm  
(p. )  
PAPER #66
- Senior Patients With Acetabular Fractures: Surprising Epidemiology and Mortality**  
*William W. Cross, III, MD<sup>1</sup>; Milton L. "Chip" Routt Jr, MD<sup>2</sup>; Sean E. Nork, MD<sup>2</sup>; James C. Krieg, MD<sup>2</sup>;*  
<sup>1</sup>Mayo Clinic, Rochester, Minnesota, USA;  
<sup>2</sup>Harborview Medical Center, Seattle, Washington, USA
- 4:20 pm  
(p. )  
PAPER #67
- Predicting the Need for Arthroplasty after Acetabular Open Reduction and Internal Fixation**  
*Rebecca Clinton, MD<sup>1</sup>; Theodore T. Manson, MD<sup>1</sup>; Renan Castillo, PhD<sup>2</sup>; Robert S. Sterling, MD<sup>1</sup>;*  
<sup>1</sup>R Adams Cowley Shock Trauma Center, Department of Orthopaedics, University of Maryland Medical School, Baltimore, Maryland, USA;  
<sup>2</sup>Center for Injury Research & Policy, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA
- 4:26 pm Discussion
- 4:31 pm Adjourn

FRIDAY, OCTOBER 5, 2012

5:30 –  
6:30 pm

**OTA Military Reception**

*(Seasons)*

Hosted by the OTA Board of Directors  
and the OTA Military Committee  
(All Active Duty Military and  
all Landstuhl Distinguished Visiting Scholar  
participants invited.)



SCHEDULE

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# 2012 OTA ANNUAL MEETING SATURDAY, OCTOBER 6, 2012

SCHEDULE

6:15 am	<b>Continental Breakfast</b> <i>(Available at Breakout Sessions)</i>
	<b>Attendee Registration</b> <i>(Convention Center Foyer Ballroom AB)</i>
6:30 am	<b>Speaker Ready Room</b> <i>(Convention Center 202 AB)</i>
7:00 am	<b>Scientific Posters</b> (Technical Exhibits Open at 9:00 am) <i>(Convention Center Hall C)</i>
	<b>Continental Breakfast</b> <i>(Convention Center Hall C)</i>
6:30 - 7:45 am (Notes p. )	<b>Concurrent Breakout Sessions</b> a) Skills Labs b) Case Presentations

6:30 –  
7:45 am

## SKILLS LABS

*Tickets Required*

**ORIF Periprosthetic Fractures of the Femur (#S1)** (M100 EF)  
 Moderator: *Raymond R. White, MD*  
 Faculty: *David B. Carmack, MD; Hans-Christoph Pape, MD; J. Spence Reid, MD; Nirmal C. Tejwani, MD and Lawrence X. Webb, MD*

6:30 –  
7:45 am

## CASE PRESENTATIONS

*No Tickets Required*

**Proximal Humerus Fractures** (200 ABC)  
 Moderator: *Michael J Gardner, MD*  
 Faculty: *Samir Mehta, MD and Andrew H. Schmidt, MD*

**Distal Femoral Fractures** (200 DE)  
 Moderator: *Darin Freiss, MD*  
 Faculty: *Amer J. Mirza, MD; David C. Templeman, MD and Heather H. Vallier, MD*

**Post-traumatic Infection** (200 FG)  
 Moderator: *Utku Kandemir, MD*  
 Faculty: *Animesh Agarwal, MD and Bruce H. Ziran, MD*

*continued next page*

See pages 97 - 144 for financial disclosure information.

**6:30 – 7:45 am CASE PRESENTATIONS, continued**

- Management of Physeal Fractures Around the Knee and Ankle** (200 HIJ)  
 Moderator: *David A. Podeszwa, MD*  
 Faculty: *Christina A. Ho, MD; Anthony I. Riccio, MD and Robert L. Wimberly, MD*
- Scapula Fracture Injuries and Treatment** (208 AD)  
 Moderator: *William T. Obremskey, MD*  
 Faculty: *Peter A. Cole, MD and Clifford B. Jones, MD*

8:00 - 9:30 am **Concurrent Sessions (Mini Symposia and Scientific Session run concurrently.)**  
 a) Mini Symposia  
 b) Scientific Session V: Femur /Tibia/ Knee Papers (Ballroom AB)

**8:00 – 9:30 am MINI SYMPOSIA No Tickets Required**

- Two Minutes / Two Slides: Focus on the Pelvis and Acetabulum** (101 GH)  
 Moderator: *Pierre Guy, MD, MBA*  
 Faculty: *Kelly A. Lefavre, MD; Christopher G. Moran, MD; Jason W. Nascone, MD; H. Claude Sagi, MD; Adam J. Starr, MD and David J. Stephen, MD*
- Preoperative Nightmares in Orthopaedic Trauma: Deal with It** (101 IJ)  
 Moderator: *John T. Gorczyca, MD*  
 Faculty: *Michael A. Miranda, MD; Kevin J. Pugh, MD; Michael S. Sirkin, MD and Jeffrey M. Smith, MD*

**SCIENTIFIC SESSION V FEMUR and TIBIAL FRACTURES and KNEE INJURIES**  
**8:00 – 9:30 am Moderators - Michael J. Gardner, MD & Robert F. Ostrum, MD**

- 8:00 am (p. ) PAPER #68 **How High Can You Go: Retrograde Nailing of Proximal Femur Fractures**  
*Lisa K. Cannada, MD; Kevin M. Kuhn, MD; J. Tracy Watson, MD; Southeast Fracture Consortium; Saint Louis University Hospital, Saint Louis, Missouri, USA*
- 8:06 am (p. ) PAPER #69 **Gait Analysis After Retrograde and Trochanteric Entry Intramedullary Nail Fixation of Femoral Shaft Fractures**  
*Kellen L. Huston, MD; J. Tracy Watson, MD; Lisa K. Cannada, MD; Saint Louis University Department of Orthopaedic Surgery, Saint Louis, Missouri, USA*

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**SATURDAY, OCTOBER 6, 2012**

- 8:12 am  
(p. )  
PAPER #70
- Δ Radiographic Outcomes of Closed Diaphyseal Femur Fractures Treated With the SIGN Nail**  
*Sasha P. Carsen, MD; Si-Hyeong Park, MD; David A. Simon, MD; Robert J. Feibel, MD;*  
*University of Ottawa/The Ottawa Hospital, Ottawa, Ontario, Canada*
- 8:18 am
- Discussion
- 8:23 am  
(p. )  
PAPER #71
- Clinical and Functional Outcomes in Patients Who Sustained Bisphosphonate-Associated Complete Femur Fractures**  
*Kenneth A. Egol, MD; Ji Hae Park, BS; Zehava Sadka Rosenberg, MD; Valerie H. Peck, MD; Nirmal C. Tejwani, MD;*  
*NYU Hospital for Joint Diseases, New York, New York, USA*
- 8:29 am  
(p. )  
PAPER #72
- Why are Reported Nonunion Rates After Locked Plate Fixation of Distal Femur Fractures so Variable? A Multicenter Retrospective Study of 284 Fractures**  
*Edward K. Rodriguez, MD, PhD<sup>1</sup>; Michael J. Weaver, MD<sup>2</sup>;*  
*Lindsay M. Herder, BA<sup>1</sup>; Jordan H. Morgan, BS<sup>2,3</sup>; David Zurakowski, MD<sup>4</sup>;*  
*Paul T. Appleton, MD<sup>1</sup>; Mark S. Vrahas, MD<sup>2,3</sup>;*  
<sup>1</sup>*Beth Israel Deaconess Medical Center, Department of Orthopaedics, Boston, Massachusetts, USA;*  
<sup>2</sup>*Brigham and Women's Hospital, Department of Orthopaedics, Boston, Massachusetts, USA;*  
<sup>3</sup>*Massachusetts General Hospital, Department of Orthopaedics, Boston, Massachusetts, USA;*  
<sup>4</sup>*Children's Hospital, Boston, Massachusetts, USA*
- 8:35 am  
(p. )  
PAPER #73
- A Comparison of More and Less Aggressive Bone Débridement Protocols for the Treatment of Open Supracondylar Femur Fractures**  
*William M. Ricci, MD<sup>1</sup>; Cory A. Collinge, MD<sup>2</sup>; Philipp N. Streubel, MD<sup>1</sup>;*  
*Christopher M. McAndrew, MD<sup>1</sup>; Michael J. Gardner, MD<sup>1</sup>;*  
<sup>1</sup>*Washington University School of Medicine, Saint Louis, Missouri, USA;*  
<sup>2</sup>*Harris Methodist Fort Worth Hospital, Fort Worth, Texas, USA*
- 8:41 am
- Discussion
- 8:46 am  
(p. )  
PAPER #74
- Compartment Pressure Monitoring for Acute Compartment Syndrome**  
*Margaret M. McQueen, MD; Andrew D. Duckworth, MBChB, BSc (Hons);*  
*Stuart A. Aitken; Charles M. Court-Brown, MD;*  
*Edinburgh Orthopaedic Trauma Unit, Royal Infirmary of Edinburgh, Edinburgh, Scotland, United Kingdom*
- 8:52 am  
(p. )  
PAPER 75
- Radiographic Predictors of Compartment Syndrome after Tibial Fracture**  
*Chris Allmon, MD; Ebrahim Paryavi, MD, MPH; Andrew Dubina;*  
*Robert V. O'Toole, MD;*  
*R Adams Cowley Shock Trauma Center, Department of Orthopaedics, University of Maryland Medical School, Baltimore, Maryland, USA*

Δ OTA Grant

See pages 97 - 144 for financial disclosure information.

- 8:58 am  
(p. )  
PAPER #76
- NIRS Versus Direct Pressure Monitoring of Acute Compartment Syndrome in a Porcine Model**  
*Curtis J. Cathcart, DVM; Michael S. Shuler, MD; Lt Col Brett A. Freedman, MD; Lisa R. Reynolds, BS, RVT; Ashley L. Cole, MPH; Thomas E. Whitesides, Jr., MD; Emily K. Smith, MPH; Steven C. Budsberg, DVM, DAVCS; University of Georgia, Athens, Georgia, USA*
- 9:04 am  
Discussion
- 9:09 am  
(p. )  
PAPER #77
- Complications Following Tension Band Fixation of Patellar Fractures with Cannulated Screws Versus Kirschner Wires**  
*C. Max Hoshino, MD<sup>1</sup>; Wesley Huy Tran, MD, JD<sup>1</sup>; John V. Tiberi, MD<sup>1</sup>; Mary Helen Black, PhD<sup>2</sup>; Bonnie H. Li, MS<sup>2</sup>; Stuart M. Gold, MD<sup>1</sup>; Ronald A. Navarro, MD;<sup>2</sup>*  
*<sup>1</sup>Department of Orthopaedic Surgery, Harbor-UCLA Medical Center, Torrance, California, USA;*  
*<sup>2</sup>Department of Orthopaedic Surgery, Kaiser Permanente South Bay Medical Center, Harbor City, California, USA*
- 9:15 am  
(p. )  
PAPER #78
- The Incidence of Meniscal Tears Requiring Repair in Tibial Plateau Fractures: A Review of 670 Patients**  
*Daniel L. Stahl, MD; Rafael Serrano-Riera, MD; Bradley Deafenbaugh, MD; Roy Sanders, MD; H. Claude Sagi, MD;*  
*Florida Orthopedic Institute, Tampa, Florida, USA*
- 9:21 am  
(p. )  
PAPER #79
- Complications of High-Energy Bicondylar Tibial Plateau Fractures Treated With Dual Plating Through Two Incisions**  
*Michael R. Ruffolo, MD; Harvey E. Montijo; Franklin K. Gettys; Rachel B. Seymour; Madhav A. Karunakar, MD;*  
*Carolinas Medical Center, Charlotte, North Carolina, USA*
- 9:27 am  
(p. )  
PAPER #80
- Δ Risk Factors for Reoperation and Mortality Following the Operative Treatment of Tibial Plateau Fractures in Ontario 1996–2009**  
*David Wasserstein, MD, MSc<sup>1</sup>; Hans J. Kreder, MD, MPH, FRCSC<sup>1,2</sup>; Michael Paterson, MSc<sup>2</sup>; Richard J. Jenkinson, MD, FRCSC<sup>1</sup>;*  
*<sup>1</sup>Division of Orthopaedic Surgery, Sunnybrook Health Sciences Centre and University of Toronto, Toronto, Ontario, Canada;*  
*<sup>2</sup>Institute for Clinical Evaluative Sciences, Toronto, Ontario, Canada*
- 9:33 am  
Discussion
- 9:40 am  
Break  
Visit Scientific Posters & Technical Exhibits (*Convention Center Hall C*)

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**SATURDAY, OCTOBER 6, 2012**

10:10 - 11:40 am **Concurrent Sessions (*Mini Symposia and Scientific Session run concurrently.*)**  
 a) Mini Symposia  
 b) Scientific Session VI: Upper Extremity Injuries (*Ballroom AB*)

**10:10 –  
11:40 am**

**MINI SYMPOSIA**

*No Tickets Required*

**Amputations in Trauma: Getting the Most Out of Your Limb** (200 ABC)

Moderator: *Lisa K. Cannada, MD*

Faculty: *Romney C. Andersen, MD, Col, MC; Paul J. Dougherty, MD and Rahul Vaidya, MD*

**Orthobiologics: Where Do They Fit In Your Practice?** (200 DE)

Moderator: *Ross K. Leighton, MD*

Faculty: *Mohit Bhandari, MD, PhD, FRCSC; Thomas A. Russell, MD and Emil H. Schemitsch, MD*

**Multiligament Knee Dislocation Treatment** (200 FG)

Moderator: *William T. Obremskey, MD*

Faculty: *Gregory C. Fanelli, MD and James P. Stannard, MD*

**SCIENTIFIC SESSION VI  
UPPER EXTREMITY INJURIES**

**10:10 –  
11:40 am**

**Moderators - Michael D. McKee, MD & Kyle J. Jeray, MD**

10:10 am **Radial Head Instability Following Malalignment of the Proximal Ulna:  
(p. ) A Biomechanical Study**

PAPER #81

*Emilie Sandman, MD<sup>1,2</sup>; Fanny Canet, Ing Jr, MScA<sup>1</sup>; Yoan Petit, PhD<sup>1,3</sup>;*

*G. Yves Laflamme, MD, FRCSC<sup>1</sup>; George S. Athwal, MD, FRCSC<sup>4</sup>;*

*Dominique M. Rouleau, MD, MSc, FRCSC<sup>1</sup>;*

<sup>1</sup>*Hôpital du Sacré-Cœur de Montréal, Montreal, Quebec, Canada;*

<sup>2</sup>*Université de Montréal, Montréal, Quebec, Canada;*

<sup>3</sup>*École de Technologie Supérieure, Montreal, Quebec, Canada;*

<sup>4</sup>*Hand and Upper Limb Center, St Joseph's Health Care,*

*University of Western Ontario, Ontario, Canada*

10:16 am **Ulnar Variance as a Predictor of Persistent Instability Following Galeazzi  
(p. ) Fracture-Dislocations**

PAPER #82

*Richelle C. Takemoto, MD<sup>1</sup>; Igor Immerman, MD<sup>1</sup>; Michelle Sugi, MD<sup>2</sup>;*

*Nirmal C. Tejwani, MD<sup>1</sup>; Kenneth A. Egol, MD<sup>1</sup>;*

<sup>1</sup>*NYU Hospital for Joint Diseases, New York, New York, USA*

<sup>2</sup>*LAC-USC Medical Center, Los Angeles, California, USA*

10:22 am Discussion

See pages 97 - 144 for financial disclosure information.



- 10:27 am  
(p. )  
PAPER #83
- Pathoanatomical Considerations and Implications of Heterotopic Ossification Following Surgical Treatment of Elbow Trauma**  
*Bryce T. Gillespie, MD; George S.M. Dyer, MD;*  
*Division of Hand and Upper Extremity Surgery, Department of Orthopaedic Surgery, Brigham and Women's Hospital, Boston, Massachusetts, USA*
- 10:33 am  
(p. )  
PAPER #84
- Nonoperative Management of Displaced Olecranon Fractures**  
*Andrew D. Duckworth, MBChC, BSc (Hons); Kate E. Bugler;*  
*Nicholas D. Clement, MBBS; Charles M. Court-Brown, MD;*  
*Margaret M. McQueen, MD;*  
*Edinburgh Orthopaedic Trauma Unit, Royal Infirmary of Edinburgh, Edinburgh, Scotland, United Kingdom*
- 10:39 am
- Discussion
- 10:44 am  
(p. )  
PAPER #85
- Minimally Displaced Clavicle Fracture on Initial Trauma Survey: A Benign Injury?**  
*John Riehl, MD; Bill Athans, MD; Mark Munro, MD; Joshua Langford, MD;*  
*Stanley Kupiszewski, MD; George J. Haidukewych, MD; Kenneth J. Koval, MD;*  
*Orlando Regional Medical Center, Orlando, Florida, USA*
- 10:50 am  
(p. )  
PAPER #86
- Progressive Displacement After Clavicle Fracture: An Observational Study**  
*Erich M. Gauger, MD<sup>1</sup>; Aaron R. Jacobson, DC<sup>1</sup>; Ryan E. Will, MD<sup>2</sup>;*  
*Peter A. Cole, MD<sup>1</sup>;*  
<sup>1</sup>*University of Minnesota, Minneapolis, Minnesota, USA;*  
<sup>2</sup>*Multicare Health System, Tacoma, Washington, USA*
- 10:56 am  
(p. )  
PAPER #87
- Prognostic Factors for Reoperation Following Plate Fixation of Fractures of the Midshaft Clavicle**  
*Laura A. Schemitsch; Emil H. Schemitsch, MD; Paul R. Kuzysk, MD;*  
*Michael D. McKee, MD; Milena R. Vicente, RN, CCRP;*  
*St. Michael's Hospital, Toronto, Ontario, Canada*
- 11:02 am
- Discussion
- 11:07 am  
(p. )  
PAPER #88
- Four-Part Fractures of the Proximal Humerus: Outcomes of Surgical and Nonsurgical Management**  
*Brian D. Solberg, MD; David A. Friedberg, MD; Dennis P. Franco, MD;*  
*California Hospital Medical Center, Los Angeles, California, USA*
- 11:13 am  
(p. )  
PAPER #89
- Fractures of the Greater Tuberosity of the Humerus: A Study of Associated Rotator Cuff Injury and Atrophy**  
*Luojun Wang<sup>1</sup>; Jennifer Mutch<sup>2</sup>; George-Yves Laflamme, MD<sup>2</sup>;*  
*Nicola Hagemeister<sup>3</sup>; Dominique M. Rouleau, MD<sup>2</sup>;*  
<sup>1</sup>*Université de Montréal, Montreal, Quebec, Canada;*  
<sup>2</sup>*Hôpital du Sacré-Coeur de Montréal, Université de Montréal, Montreal, Quebec, Canada;*  
<sup>3</sup>*Centre Hospitalier de l'Université de Montréal, École de Technologie Supérieure, Montreal, Quebec, Canada*

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## SATURDAY, OCTOBER 6, 2012

- 11:19 am  
(p. )  
PAPER #90
- The Impact of Preoperative Coronal Plane Deformity on Proximal Humerus Fixation With Endosteal Augmentation**  
*Milton T.M. Little, MD; Marschall B. Berkes, MD; Patrick C. Schottel, MD; Lionel E. Lazarao, MD; Lauren E. Lamont, MD; Nadine C. Pardee, BS; David L. Helfet, MD; Dean G. Lorich, MD; Hospital for Special Surgery/New York Presbyterian-Cornell, New York, New York, USA*
- 11:25 am  
Discussion
- 11:30 am  
(p. )  
PAPER #91
- Δ Operative Versus Nonoperative Treatment of Acute Dislocations of the Acromioclavicular Joint: Results of a Multicenter Randomized, Prospective Clinical Trial**  
*Michael D. McKee, MD; Stéphane Pelet, MD, PhD, FRCSC; Milena R. Vicente, RN, CCRP; The Canadian Orthopaedic Trauma Society (COTS) Group; St. Michael's Hospital, Toronto, Ontario, Canada*
- 11:36 am  
(p. )  
PAPER #92
- Acute Compartment Syndrome of the Forearm**  
*Andrew D. Duckworth, MBChB, BSc (Hons); Sarah E. Mitchell, MRCSEd; Samuel G. Molyneux, MRCSEd; Timothy O. White, MD, FRCS; Charles M. Court-Brown, MD; Margaret M. McQueen, MD; Edinburgh Orthopaedic Trauma Unit, Royal Infirmary of Edinburgh, Edinburgh, Scotland, United Kingdom*
- 11:42 am  
(p. )  
PAPER #93
- Cast Immobilization With and Without Immobilization of the Thumb for Nondisplaced Scaphoid Waist Fractures: A Multicenter Randomized Controlled Trial**  
*Geert A. Buijze, MD; J. Carel Goslings, MD; Steven J. Rhemrev, MD; Alexander A. Weening, MD; Bart Van Dijkman, MD; Job N. Doornberg, MD; David C. Ring, MD, PhD; CAST (Collaborative Ankle Support Trial) Collaboration; Massachusetts General Hospital, Boston, Massachusetts, USA*
- 11:48 am  
Discussion
- 11:53 am  
(p. )  
PAPER #94
- The Correlation of Age and Short-Term Outcomes in Patients Who Have Undergone Operative Fixation of Distal Radius Fractures**  
*John W. Karl, MD, MPH; Patrick R. Olson, MD, MS, MPH; Melvin P. Rosenwasser, MD; Columbia University Medical Center, Department of Orthopedics, New York, New York, USA*
- 11:59 am  
(p. )  
PAPER #95
- Alignment in Nonoperatively Treated Distal Radius Fractures: Are Our Current Predictors Predictive?**  
*Joey Lamartina, MD; Charlton Stucken, MD; Andrew Jawa, MD; Paul Tornetta III, MD; Boston University Medical Center, Boston, Massachusetts, USA*
- 12:05 pm  
Discussion

Δ OTA Grant

See pages 97 - 144 for financial disclosure information.

12:10 pm Lunch  
**LAST OPPORTUNITY TO VISIT Scientific Posters & Technical Exhibits**

12:15 pm – **Guided Poster Tours & Lunch** (*tickets required*)  
 1:00 pm **Upper Extremity (#P3)**  
*David C. Ring, MD*  
**General Interest / Polytrauma / Geriatrics (#P4)**  
*Lisa K. Cannada, MD*

1:15 - 2:45 pm **Concurrent Sessions (Mini Symposia and Scientific Session run concurrently.)**  
 a) Mini Symposia  
 b) Scientific Session VII: Topics of General Interest (*Ballroom AB*)

1:15 – 2:45 pm	MINI SYMPOSIA	No Tickets Required
	<b>Alternative Solutions in Post-Traumatic Reconstruction: I Need to Make Bone</b> Moderator: <i>Samir Mehta, MD</i> Faculty: <i>Stephen Kovach, MD; L. Scott Levin, MD; Stephen M. Quinnan, MD</i> and <i>Robert D. Zura, MD</i>	(200 ABC)
	<b>Pediatric Polytrauma: Navigating Gator Country</b> Moderator: <i>Charles T. Mehlman, DO, MPH</i> Faculty: <i>Richard Falcone, Jr., MD</i> and <i>Steven L. Frick, MD</i>	(200 DE)
	<b>Management of Complex Elbow Trauma</b> Moderator: <i>Kagan Ozer, MD</i> Faculty: <i>Jeffrey F. Lawton, MD</i> and <i>Rick Papandrea, MD</i>	(200 FG)

**SCIENTIFIC SESSION VII  
 TOPICS OF GENERAL INTEREST**  
 1:15 –  
 2:45 pm **Moderators - Gregory T. Altman, MD & Robert V. O’Toole, MD**

1:15 pm **Optimal Timing for Femoral Shaft Fracture Fixation Depends on**  
 (p. ) **Injury Severity Score and Age**  
 PAPER #96 *Sara C. Graves, MD; Robert Victor Cantu, MD; Kevin F. Spratt, PhD;*  
*Dartmouth Hitchcock Medical Center, Lebanon, New Hampshire, USA*

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SATURDAY, OCTOBER 6, 2012

- 1:21 pm  
(p. )  
PAPER #97
- Six Years' Experience With the Reamer-Irrigator-Aspirator: Impact on Healing and Pulmonary Complications Rates in Femoral Shaft Fractures**  
*Anthony J. Bell, MD; Pratik P. Desai, MD; Michael Suk, MD, JD, MPH; University of Florida College of Medicine–Jacksonville, Department of Orthopaedic Surgery, Jacksonville, Florida, USA*
- 1:27 pm  
(p. )  
PAPER #98
- Duration of Fracture Fixation Surgery in Multitrauma Patients**  
*Christopher E. Mutty, MD; Lars M. Qvick, MD; Mark J. Anders, MD; Cathy M. Buyea, MS; Lawrence B. Bone, MD; State University of New York at Buffalo, Erie County Medical Center, Buffalo, New York, USA*
- 1:33 pm
- Discussion
- 1:38 pm  
(p. )  
PAPER #99
- Risk of Obtaining Routine Cultures During Presumed Aseptic Orthopaedic Procedures**  
*Matthew A. Napierala, MD; Jaime L. Bellamy, DO; Clinton K. Murray, MD; Joseph C. Wenke, PhD; Joseph R. Hsu, MD; Skeletal Trauma Research Consortium (STReC); San Antonio Military Medical Center, Fort Sam Houston, Texas, USA*
- 1:44 pm  
(p. )  
PAPER #100
- Rapid Polymerase Chain Reaction Test for Methicillin-Resistant *Staphylococcus aureus* in Orthopaedic Trauma**  
*Holman Chan, MD; John P. Ketz, MD; Catherine A. Humphrey, MD; Jonathan M. Gross, MD; Robert F. Betts; John T. Gorczyca, MD; University of Rochester Medical Center, Rochester, New York, USA*
- 1:50 pm  
(p. )  
PAPER #101
- Conventional Compressive Dressings Superior to Negative-Pressure Dressings for Split-Thickness Skin Graft Coverage of Traumatic Extremity Wounds**  
*Laurence B. Kempton, MD; Timothy Larson, MD; Harvey Montijo, MD; Stephen H. Sims, MD; Madhav A. Karunakar, MD; Stanley Getz, MD; James F. Kellam, MD, Michael J. Bosse, MD; Carolinas Medical Center, Charlotte, North Carolina, USA*
- 1:56 pm
- Discussion
- 2:01 pm  
(p. )  
PAPER #102
- Δ Utilization of Two Grading Systems in Determining Risks Associated With Fracture Fixation in Multiply Injured Patients**  
*Nickolas J. Nahm, MD; Heather A. Vallier, MD; Timothy A. Moore, MD; MetroHealth Medical Center, Cleveland, Ohio, USA*
- 2:07 pm  
(p. )  
PAPER #103
- The Influence of Insurance Status on the Surgical Treatment of Acute Spinal Fractures**  
*Michael C. Daly, MSc; S. Samuel Bederman, MD, PhD, FRCSC; University of California, Irvine Medical Center, Department of Orthopaedic Surgery, Orange, California, USA*

Δ OTA Grant

See pages 97 - 144 for financial disclosure information.

- 2:13 pm  
(p. )  
PAPER #104      **Prevalence of Vitamin D Insufficiency in Orthopaedic Trauma Patients**  
*Brett D. Crist, MD, FACS; Michael A. Hood, MD; Gregory J. Della Rocca, MD, PhD; James P. Stannard, MD; David A. Volgas, MD; Yvonne M. Murtha, MD; University of Missouri, Columbia, Missouri, USA*
- 2:19 pm      Discussion
- 2:24 pm  
(p. )  
PAPER #105      **The Cost Effectiveness and Utility of Trauma Center Care Following Major Lower Extremity Trauma**  
*Herman S. Johal, MD, MPH<sup>1</sup>; Ellen J. MacKenzie, PhD<sup>2</sup>; <sup>1</sup>University of Calgary, Health Sciences Centre, Calgary, Alberta, Canada; <sup>2</sup>Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA*
- 2:30 pm  
(p. )  
PAPER #106      **Operating Room Efficiency: Benefits of an Orthopaedic Traumatologist at a Level II Trauma Center**  
*Peter L. Althausen, MD, MBA; Daniel John Coll, MHS, PA-C; Timothy J. O'Mara, MD; Timothy J. Bray, MD; Reno Orthopaedic Clinic, Reno, Nevada, USA*
- 2:36 pm  
(p. )  
PAPER #107      **The PROMIS Physical Function Computerized Adaptive Test Is as Reliable and Valid as the Short Musculoskeletal Function Assessment in the Orthopaedic Trauma Population With Less Ceiling Effect**  
*Man Hung, PhD; Thomas F. Higgins, MD; Charles L. Saltzman, MD; Ami R. Stuart, PhD; Shirley Hon; Stefan Rhodewalt; Ashley M. Woodbury, BS; Gregory M. Daub, BS; Erik N. Kubiak, MD; University of Utah Department of Orthopaedic Surgery, Salt Lake City, Utah, USA*
- 2:42 pm      Discussion
- 2:47 pm      Break

3:17 –  
4:03 pm

**SCIENTIFIC SESSION VIII  
PEDIATRIC FRACTURES**

Moderators - Victor A. de Ridder, MD & Kelly L. VanderHave, MD

- 3:17 pm  
(p. )  
PAPER #108      **Epidemiology of Vascular Complications in Supracondylar Humerus Fractures in the United States**  
*Joshua Roehrich, MD<sup>1</sup>; Charles T. Mehlman, DO, MPH, Jun Ying, PhD<sup>1</sup>; <sup>1</sup>University of Cincinnati, Cincinnati, Ohio, USA; <sup>2</sup>Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA*
- 3:23 pm  
(p. )  
PAPER #109      **Complications of Retained Hardware After Plate Fixation of the Pediatric Forearm**  
*Bryan G. Vopat, MD; Peter G. Fitzgibbons, MD; Patrick M. Kane, MD; Christopher J. Got, MD; Julia A. Katarincic, MD; Rhode Island Hospital, Providence, Rhode Island, USA*

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SATURDAY, OCTOBER 6, 2012

- 3:29 pm  
(p. )  
PAPER #110
- Both-Bone Forearm Fractures in Children and Adolescents: Which Fixation Strategy is Superior? A Systematic Review**  
*Keith D. Baldwin, MD, MSPT, MPH; Martin J. Morrison III, MD; Lauren A. Tomlinson, BS; John M. Flynn, MD*  
*The Children's Hospital of Philadelphia, Department of Orthopaedic Surgery, Philadelphia, Pennsylvania, USA*
- 3:35 pm
- Discussion
- 3:40 pm  
(p. )  
PAPER #111
- SCRATCH (Self Cast Removal at the Child's Home): Treatment of Stable Pediatric Forearm Fractures Using Home Removable Casts Compared With Traditional Cast Therapy: A Prospective Randomized Controlled Trial**  
*Thomas W. Hamilton, MBChB; Lynne Hutchings, MRCS; Jennie Wakefield; Joseph Alousou, MRCS; Elizabeth Tutton; Emma Hodson; Clare Smith; Bridget Gray; Susanna Symonds; Keith M. Willett, MD*  
*The Kadoorie Centre for Critical Care Research and Education, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, John Radcliffe Hospital, Oxford, United Kingdom*
- 3:46 pm  
(p. )  
PAPER #112
- Do Any Factors Influence the Development of Femoral Head Osteonecrosis in Pediatric Femoral Neck Fractures?**  
*Patrick M. Riley Jr, MD<sup>1</sup>; Melanie A. Morscher, BS<sup>2</sup>; M. David Gothard, MS<sup>3</sup>; Patrick M. Riley, MD<sup>2</sup>;*  
*<sup>1</sup>Summa Health System, Akron, Ohio, USA;*  
*<sup>2</sup>Akron Children's Hospital, Akron, Ohio, USA;*  
*<sup>3</sup>Biostats, East Canton, Ohio, USA*
- 3:52 pm  
(p. )  
PAPER #113
- Salter-Harris II Fractures of the Distal Tibia: Does Surgical Management Reduce the Risk of Premature Physeal Closure?**  
*Franco Russo; Molly A. Moor, MPH; Scott J. Mubarak, MD; Andrew T. Pennock, MD;*  
*Rady Children's Hospital, San Diego, California, USA*
- 3:58 pm
- Discussion

SCIENTIFIC SESSION IX  
TIBIAL FRACTURES

4:03 –

4:49 pm

Moderators - Thomas F. Higgins, MD & Theodore T. Manson, MD

- 4:03 pm  
(p. )  
PAPER #114
- Character, Incidence, and Predictors of Knee Pain and Activity After Intramedullary Nailing of an Isolated Tibia Fracture**  
*William T. Obremskey, MD, MPH<sup>1</sup>; Julie Agel, ATC<sup>2</sup>; Kristin Archer, PhD<sup>1</sup>; Paul Tornetta III, MD<sup>3</sup>; for the SPRINT (Study to Prospectively evaluate Reamed Intramedullary Nails in Tibial fractures) Investigators;*  
*<sup>1</sup>Vanderbilt University Medical Center, Nashville, Tennessee, USA;*  
*<sup>2</sup>Harborview Medical Center, Seattle, Washington, USA;*  
*<sup>3</sup>Boston Medical Center, Boston, Massachusetts, USA*

See pages 97 - 144 for financial disclosure information.

4:09 pm  
(p. )  
PAPER #115

**Intramedullary Nailing of the Tibia via a Suprapatellar Approach: Radiographic Results and Clinical Outcomes at a Minimum of 12 Months Follow-up**  
*Charles J. Jordan, MD; Thomas G. DiPasquale, DO; H. Claude Sagi, MD; John A. Arrington, MD; Roy Sanders, MD;*  
*Orthopaedic Trauma Service, Florida Orthopaedic Institute, Tampa, Florida, USA*

4:15 pm  
(p. )  
PAPER #116

**Intramedullary Nailing for Distal Tibial Fractures**  
*Christiane G. Kruppa, MD<sup>1</sup>; Martin F. Hoffmann, MD<sup>1</sup>; Michelle B. Mulder, BS<sup>2</sup>; Debra L. Sietsema, PhD<sup>3</sup>; Clifford B. Jones, MD<sup>3</sup>;*  
*<sup>1</sup>Grand Rapids Medical Education Partners, Grand Rapids, Michigan, USA;*  
*<sup>2</sup>Wayne State University, Detroit, Michigan, USA;*  
*<sup>3</sup>Orthopaedic Associates of Michigan, Michigan State University, Grand Rapids, Michigan, USA*

4:21 pm

Discussion

4:26 pm  
(p. )  
PAPER #117

**Validation of the OTA Open Fracture Classification With Data From a Prospective Cohort Study of Limb-Threatening Tibia Fractures**  
*Clifford B. Jones, MD<sup>1</sup>; Renan C. Castillo, PhD<sup>2</sup>; Anthony R. Carlini, MS<sup>2</sup>; Debra L. Sietsema, PhD, RN<sup>1</sup>; MAJ Kenneth J. Nelson, MD<sup>3</sup>;*  
*LTC Anthony E. Johnson, MD<sup>3</sup>; Michael J. Bosse, MD<sup>4</sup>; Ellen J. MacKenzie, PhD<sup>2</sup>;*  
*for the LEAP (Lower Extremity Assessment Project) Study Group;*  
*<sup>1</sup>Orthopaedic Associates of Michigan, Michigan State University, Grand Rapids, Michigan, USA;*  
*<sup>2</sup>Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA;*  
*<sup>3</sup>Brooke Army Medical Center, San Antonio, Texas, USA;*  
*<sup>4</sup>Carolinas Medical Center, Charlotte, North Carolina, USA*

4:32 pm  
(p. )  
PAPER #118

**Soft-Tissue Injury Predictors of Amputation Following Severe Open Tibia Fractures**  
*MAJ Kenneth J. Nelson, MD<sup>1</sup>; LTC Anthony E. Johnson, MD<sup>2</sup>;*  
*Clifford B. Jones, MD<sup>3</sup>; Renan C. Castillo, PhD<sup>4</sup>; Anthony R. Carlini, MS<sup>4</sup>;*  
*Michael J. Bosse, MD<sup>5</sup>; Ellen J. MacKenzie, PhD<sup>4</sup>;*  
*for the LEAP (Lower Extremity Assessment Project) Study Group;*  
*<sup>1</sup>William Beaumont Army Medical Center, El Paso, Texas, USA;*  
*<sup>2</sup>Brooke Army Medical Center, San Antonio, Texas, USA;*  
*<sup>3</sup>Orthopaedic Associates of Michigan, Michigan State University, Grand Rapids, Michigan, USA;*  
*<sup>4</sup>Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA;*  
*<sup>5</sup>Carolinas Medical Center, Charlotte, North Carolina, USA*

4:38 pm  
(p. )  
PAPER #119

**Predictive Radiographic Markers for Concomitant Ipsilateral Ankle Injuries in Tibial Shaft Fractures**  
*Patrick Schottel, MD; Marschall B. Berkes, MD; Milton T. M. Little, MD;*  
*Lionel E. Lazaro, MD; David L. Helfet, MD; Dean G. Lorich, MD;*  
*Hospital for Special Surgery, New York, New York, USA*

4:44 pm

Discussion

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**SATURDAY, OCTOBER 6, 2012**

**SCHEDULE**

4:49 pm Closing Remarks

4:55 pm Adjourn

See pages 97 - 144 for financial disclosure information.



# OTA 2012 ANNUAL MEETING SCIENTIFIC POSTERS

Minneapolis Convention Center Hall C will be open:

Thursday 2:30 pm – 5:00 pm

Friday 6:30 am – 5:00 pm

Saturday 6:30 am – 1:30 pm

Key: Δ = presentation was funded by an OTA administered grant  
Names in bold = Presenter

POSTERS

## HIP/FEMUR

### Poster #1

(p. )

### Results of Complex Proximal Femur Fractures Treated With Locking Proximal Femur Plates

**Cory A. Collinge, MD<sup>1</sup>**; Timothy Weber, MD<sup>2</sup>; J. Tracy Watson, MD<sup>3</sup>; Michael Archdeacon, MD<sup>4</sup>; David Lowenberg, MD<sup>5</sup>; David Zamarano, MD<sup>6</sup>; Florian Huber, MD<sup>7</sup>; Michael Prayson, MD<sup>8</sup>; Timothy Achor, MD<sup>9</sup>;

<sup>1</sup>Harris Methodist Fort Worth Hospital, Fort Worth, Texas, USA;

<sup>2</sup>OrthoIndy, Indianapolis, Indiana, USA;

<sup>3</sup>Saint Louis University School of Medicine, Saint Louis, Missouri, USA;

<sup>4</sup>University of Cincinnati Academic Medical Center, Cincinnati, Ohio, USA;

<sup>5</sup>Stanford University Medical Center, Palo Alto, California, USA;

<sup>6</sup>University of California, Irvine Medical Center, Anaheim, California, USA;

<sup>7</sup>Peninsula Orthopedic Associates, Salisbury, Maryland, USA;

<sup>8</sup>Miami Valley Hospital, Dayton, Ohio, USA;

<sup>9</sup>University of Texas, Houston Medical Center, Houston, Texas, USA

### Poster #2

(p. )

### Distal Femoral Anterior Cortical Penetration After Intramedullary Hip Nailing: Fact or Fiction?

**Dan Bazylewicz, MD<sup>1</sup>**; Kenneth A. Egol, MD<sup>1</sup>; Kenneth J. Koval, MD<sup>2</sup>;

<sup>1</sup>NYU/Hospital for Joint Diseases, New York, New York, USA;

<sup>2</sup>Orlando Regional Medical Center, Orlando, Florida, USA

### Poster #3

(p. )

### Early Intervention for Better Survival Rate After Hip Fracture

Ely L. Steinberg, MD; Amir Sternheim, MD; Assaf Kadar, MD;

Ahuva Melik, MD; **Moshe Salai, MD**; Ofir Chechik, MD;

Orthopaedic Department, Sourasky Tel-Aviv Medical Center,

Tel-Aviv University, Tel-Aviv, Israel

### Poster #4

(p. )

### The Effects of “Old” Red Blood Cell Transfusion on Mortality and Morbidity in Elderly Patients With Hip Fractures

**Assaf Kadar, MD**; Ofir Chechik, MD; Gabby Meghiddo, MD;

Amir Sternheim, MD;

Department of Orthopedics, Tel Aviv Sourasky Medical Center,

Sackler Faculty of Medicine, Tel Aviv University, Ramat Aviv, Israel

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## SCIENTIFIC POSTERS

- Poster #5**  
(p. )  
**The Incidence of Femoral Neck Fractures Associated With Floating Knee Injuries**  
*Bret D. Beavers, MD<sup>1</sup>; Robert N. Reddix, Jr., MD<sup>1,2</sup>; Terry E. Rives, PhD, MPH<sup>1</sup>;*  
*<sup>1</sup>John Peter Smith Hospital Orthopaedic Surgery Residency Program, Fort Worth, Texas, USA;*  
*<sup>2</sup>University of North Texas Health Science Center, Fort Worth, Texas, USA*
- Poster #6**  
(p. )  
**Intramedullary Nailing of Subtrochanteric Fractures: Does Malreduction Matter?**  
*John Riehl, MD; George J. Haidukewych, MD; Mark W. Munro, MD;*  
*Joshua Langford, MD; Stanley Kupiszewski, MD; Kenneth J. Koval, MD;*  
*Orlando Regional Medical Center, Orlando, Florida, USA*
- Poster #7**  
(p. )  
**New Oral Antithrombotic for Hip Fracture: A Standardized Protocol**  
*Daniel Godoy, MD<sup>1</sup>; Alberto Cid Casteulani, MD<sup>2</sup>; Kenneth Iserson, MD<sup>3</sup>;*  
*Santiago Svarzchtein, MD<sup>2</sup>; Eliseo Firman, MD<sup>2</sup>; Sebastian Sasaki, MD<sup>2</sup>;*  
*Diego Roncolato, MD<sup>2</sup>;*  
*<sup>1</sup>Hospital Italiano de Buenos Aires, Buenos Aires Argentina;*  
*<sup>2</sup>Centro Medico Integral Fitz Roy, Buenos Aires, Argentina;*  
*<sup>3</sup>University of Arizona, Tucson, Arizona, USA*
- Poster #8**  
(p. )  
**Proximal Femoral Replacement in the Management of Acute Periprosthetic Fractures of the Hip: A Competing Risks Survival Analysis**  
*Matthew Colman, MD<sup>1</sup>; Lisa Choi, MD<sup>1</sup>; Antonia Chen, MD<sup>1</sup>;*  
*Dan Winger, MS<sup>2</sup>; Peter Siska, MD<sup>1</sup>; Mark Goodman, MD<sup>1</sup>;*  
*Lawrence Crossett, MD<sup>1</sup>; Ivan S. Tarkin, MD<sup>1</sup>; Richard McGough, MD<sup>1</sup>;*  
*<sup>1</sup>Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, Pennsylvania, USA;*  
*<sup>2</sup>Clinical and Translational Science Institute (CTSI), University of Pittsburgh, Pittsburgh, Pennsylvania, USA*
- Poster #9**  
(p. )  
**Assessment of Perfusion to the Femoral Head and Head-Neck Junction Following Surgical Hip Dislocation Using Gadolinium-Enhanced Magnetic Resonance Imaging**  
*Lionel E. Lazaro, MD<sup>1</sup>; David S. Wellman, MD<sup>1</sup>; Peter K. Sculco, MD<sup>1</sup>;*  
*Craig E. Klinger, BS<sup>1</sup>; Jonathan P. Dyke, PhD<sup>2</sup>; Nadine C. Pardee, BS<sup>1</sup>;*  
*Edwin P. Su, MD<sup>1</sup>; David L. Helfet, MD<sup>1</sup>; Dean G. Lorich, MD<sup>1</sup>;*  
*<sup>1</sup>Hospital for Special Surgery and Weill Medical College of Cornell University, New York, New York, USA;*  
*<sup>2</sup>Citigroup Biomedical Imaging Center, Weill Medical College of Cornell University, New York, New York, USA*
- Poster #10**  
(p. )  
**Aseptic Diaphyseal Femoral Nonunions: Exchange Intramedullary Nailing Versus Dynamization**  
*Jeffrey P. Garrett, MD; Rafael Serrano-Riera, MD; Michael Doarn, MD;*  
*H. Claude Sagi, MD;*  
*Orthopaedic Trauma Service, Florida Orthopaedic Institute, Tampa, Florida, USA*

- Poster #11**  
(p. )  
**Is Operative Delay in Hip Fracture Patients on Clopidogrel (Plavix) Warranted? A Comorbidity Matched Analysis**  
*Chris Casstevens, MD; J. Patrick Martens; Michael T. Archdeacon, MD; B. J. Johnson; Theodore Toan Le, MD; John D. Wyrick; Department of Orthopaedic Surgery, University of Cincinnati Medical Center, Cincinnati, Ohio, USA*
- Poster #12**  
(p. )  
**Surgical Time of Day Does Not Affect Outcome Following Hip Fracture Fixation**  
*Ryan E. Bennett, MD; Andrea J. Vlasak, MD; Steve R. Gammon, MD; Sandy Vang, BS; Julie A. Switzer, MD; University of Minnesota/Regions Hospital, Minneapolis-St. Paul, Minnesota, USA*
- Poster #13**  
(p. )  
**Morphology of Displaced Paewels III Vertical Femoral Neck Fractures in Young Adults**  
*Cory A. Collinge, MD<sup>1,2</sup>; Robert N. Reddix, Jr., MD<sup>2</sup>; <sup>1</sup>Harris Methodist Fort Worth Hospital, Fort Worth, Texas, USA; <sup>2</sup>John Peter Smith Orthopedic Surgery Residency, Fort Worth, Texas, USA*
- Poster #14**  
(p. )  
**Treatment of Femoral Neck Fractures With a Novel Length-Stable Construct Leads to High Union Rates With Minimal Femoral Neck Shortening**  
*Lionel E. Lazaro, MD; Milton T.M. Little, MD; Marschall B. Berkes, MD; Patrick C. Schottle, MD; Nadine C. Pardee, BS; David L. Helfet, MD; Dean G. Lorch, MD; Hospital for Special Surgery and Weill Medical College of Cornell University, New York, New York, USA*
- Poster #15**  
(p. )  
**Preoperative Traction in Trochanteric Fractures Treated With a Gamma3 Nail: Determination of the Impact in 347 Cases**  
*Rainer H. Burgkart, MD, PhD<sup>1</sup>; Erik Wilde, MD<sup>2</sup>; Andreas Paech, MD<sup>2</sup>; Johannes Kiene<sup>2</sup>; Christian Juergens, MD<sup>2,3</sup>; Arndt P. Schulz, MD, PhD<sup>2,3</sup>; <sup>1</sup>Clinic for Orthopaedics and Traumatology, Technische Universität München, München, Germany; <sup>2</sup>University Hospital SH, Campus Lübeck, Lübeck, Germany; <sup>3</sup>BG Trauma Hospital, Hamburg, Germany*
- Poster #16**  
(p. )  
**What is the Clinical and Economic Impact of Preoperative Transthoracic Echocardiography on Elderly Patients With Hip Fractures?**  
*Andrew J. Marcantonio, MD; Brandon M. Steen, MD; Michael S. Kain, MD; Kasey J. Bramlett, PA-C; John F. Tilzey, MD; Richard Iorio, MD; Lahey Clinic Medical Center, Burlington, Massachusetts, USA*
- Poster #17**  
(p. )  
**Clinical and Economic Impact of Generic Implant Usage for the Treatment of Femoral Neck Fractures**  
*Justin R. Kauk, MD<sup>1</sup>; Peter L. Althausen, MD<sup>1</sup>, MBA; Daniel J. Coll, MHS, PA-C<sup>2</sup>; Timothy J. O'Mara, MD<sup>1</sup>; Timothy J. Bray, MD<sup>1</sup>; <sup>1</sup>Reno Orthopaedic Clinic, Reno, Nevada, USA; <sup>2</sup>Renown Regional Medical Center, Reno, Nevada, USA*

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## SCIENTIFIC POSTERS

- Poster #18**  
(p. )
- A Retrospective Study of a Comprehensive Pain Protocol Using a Continuous Fascia Iliaca Compartment Block**  
*Elizabeth Dulaney-Cripe, MD<sup>1</sup>; Scott J. Hadaway, DDS, MD<sup>2</sup>; Carole Smith, CNS, BC, CCRN<sup>2</sup>; Brett C. LaFleur, MD<sup>1</sup>; G. Ryan Rieser, MD<sup>1</sup>; Ryan D. Bauman, MD<sup>2</sup>; Michael J. Prayson, MD<sup>2</sup>; Richard T. Laughlin, MD<sup>1</sup>;*  
<sup>1</sup>Department of Orthopaedic Surgery, Wright State University, Dayton, Ohio, USA;  
<sup>2</sup>Miami Valley Hospital, Dayton, Ohio, USA
- Poster #19**  
(p. )
- Inferior Lag Screw Placement: Does the Tip-Apex Distance Really Matter?**  
*Nikhil A. Thakur, MD; Wendell M. Heard, MD; Matt Young, BS; Patrick M. Kane, MD; David Paller, MS; Christopher T. Born, MD;*  
Department of Orthopaedics, Brown University, Providence, Rhode Island, USA
- Poster #20**  
(p. )
- Re-Engineering the Management of Patients with Fragility Hip Fractures**  
*C. Michael LeCroy, MD; Martha Hoskyns, RN, BSN, MHA; Christina McQuiston, MB ChB;*  
Mission Health System, Asheville, North Carolina, USA
- Poster #21**  
(p. )
- Δ Management of Hip Fracture Patients Using a Standardized Perioperative Approach Combined With a Medical Home (MH) Primary Care Model: A New Standard for Better Outcomes?**  
*Jove H. Graham, PhD; Thomas R. Bowen, MD; Kent A. Strohecker, MS; Kaan S. Irgit, MD; Wade R. Smith, MD;*  
Geisinger Health System, Danville, Pennsylvania, USA
- Poster #22**  
(p. )
- Fate of Hip Stems After Operative Fixation of Periprosthetic Femoral Shaft Fractures**  
*Mark J. Jo, MD; Jacob X. Didesch, MD; David S. Merriman; Christopher M. McAndrew; Michael J. Gardner, MD; William M. Ricci, MD;*  
Washington University School of Medicine, Saint Louis, Missouri, USA
- Poster #23**  
(p. )
- Assessment of Radiographic Fracture Healing in Patients With Operatively Treated Femoral Neck Fractures**  
*Brad A. Petrisor, MD, FRCSC<sup>1</sup>; Olufemi R. Ayeni, MD, FRCSC<sup>1</sup>; Simrit Bains, MA<sup>1</sup>; Rajesh Chakraverty, MD, FRCSC<sup>2</sup>; Meg Chiavaras, MD, PhD, FACR, FRCPC<sup>3</sup>; Hema N. Choudur, MBBS, FRCPC<sup>3</sup>; Naveen Parasu, MBBS, FRCR, FRCPC<sup>3</sup>; Mohit Bhandari, MD, PhD, FRCSC<sup>1</sup>; on behalf of the Assessment Group for Radiographic Evaluation and Evidence (AGREE) Study Group;*  
<sup>1</sup>Department of Surgery, McMaster University, Hamilton, Ontario, Canada;  
<sup>2</sup>Department of Surgery, Toronto Western Hospital, Toronto, Ontario, Canada;  
<sup>3</sup>Department of Radiology, McMaster University, Hamilton, Ontario, Canada

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See pages 97 - 144 for financial disclosure information.

- Poster #24**  
(p. )
- New Camera-Free Fluorobased Navigation System for Accurate Lag Screw Positioning: Comparison of Conventional Versus Navigated Postoperative Outcome**  
*Rainer H. Burgkart, MD, PhD<sup>1</sup>; Heiko Gottschling, PhD Inf<sup>1</sup>; Manuel Schroeder, Dipl Inf<sup>1</sup>; Nils Reimers, Dipl Ing<sup>2</sup>; Heye Janssen<sup>3</sup>; Arndt P. Schulz, MD, PhD, MRCS<sup>3</sup>;*  
<sup>1</sup>*Clinic for Orthopaedics and Traumatology, Technische Universität München, München, Germany;*  
<sup>2</sup>*Stryker Osteosynthesis, Schönkirchen, Germany;*  
<sup>3</sup>*Department Trauma & Orthopaedics, University Hospital Lübeck, Lübeck Germany*
- Poster #25**  
(p. )
- Are Dedicated Geriatric Hip Fracture Centers Justified Economically?**  
*R. Carter Clement, MD, MBA; Jaimo Ahn, MD, PHD; Samir Mehta, MD; Michael Maiale, MBA; Joseph Bernstein, MA, MD;*  
*University of Pennsylvania Department of Orthopaedics, Philadelphia, Pennsylvania, USA*
- Poster #26**  
(p. )
- Mortality of Femoral Neck Fractures in the Elderly Based on Charlson Comorbidity Index and Treatment Modality**  
*Adam Shar, MD; Timmothy Randell, MD; Christopher D. Chaput, MD; Daniel C. Jupiter, MD; Kindyle L. Brennan, PhD; Zachary T. Hubert, BS; Robert A. Probe, MD; Michael L. Brennan, MD;*  
*Scott and White Memorial Hospital, Temple, Texas, USA*
- Poster #27**  
(p. )
- The National Hip Fracture Database in England, Wales, and Northern Ireland: Results From 50,000 Patients Treated in a 1-Year Period**  
*Christopher G. Moran; R. Wakeman; C. Currie; M. Partridge; Keith M. Willett, MD;*  
*British Orthopaedic Association and British Geriatrics Society*
- Poster #28**  
(p. )
- The Hidden Blood Loss After Hip Fracture**  
*Samuel G. Molyneux, MSc, MRCS; G. Brown, MRCS;*  
*Timothy O. White, MD, FRCS(Orth);*  
*New Royal Infirmary of Edinburgh, Edinburgh, Scotland, United Kingdom*
- Poster #29**  
(p. )
- Surgical Fixation of Vancouver Type B1 Periprosthetic Femur Fractures: A Systematic Review**  
*Niloofar Dehghan, MD; Aaron Nauth, MD; Bill Ristevski, MD; Michael D. McKee, MD; Emil H. Schemitsch, MD;*  
*Division of Orthopaedics, St. Michael's Hospital, University of Toronto, Toronto, Ontario, Canada*
- Poster #30**  
(p. )
- Radiographic Identification of Atypical Subtrochanteric and Femoral Shaft Fractures**  
*Lise A. Leveille, MD<sup>1</sup>; Penny Brasher, PhD<sup>2</sup>; Pierre Guy, MD<sup>1</sup>; Peter J. O'Brien, MD<sup>1</sup>;*  
<sup>1</sup>*Department of Orthopaedics, University of British Columbia, Vancouver, British Columbia, Canada;*  
<sup>2</sup>*Department of Statistics, University of British Columbia, Vancouver, British Columbia, Canada*

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- Poster #31**  
(p. ) **Percutaneous Plating of the Distal Femur: Risk of Injury to the Perforating Branches of the Profunda Femoris Artery**  
*Adam Baker, MD; Brent Roster, MD; Amer J. Mirza, MD;*  
*Oregon Health & Sciences University, Portland, Oregon, USA*
- Poster #32**  
(p. ) **Ipsilateral Femoral Neck and Shaft Fractures: Results of Treatment With Hip Screws and a Retrograde Intramedullary Nail**  
**Robert F. Ostrum, MD<sup>1</sup>; Paul Tornetta, III, MD<sup>2</sup>; J. Tracy Watson, MD<sup>3</sup>;**  
*Anthony Christiano<sup>2</sup>; Emily Vafek, MD<sup>4</sup>;*  
*<sup>1</sup>Cooper University Hospital, Camden, New Jersey, USA*  
*<sup>2</sup>Boston University Medical Center, Boston, Massachusetts, USA;*  
*<sup>3</sup>Saint Louis University, Saint Louis, Missouri, USA;*  
*<sup>4</sup>Wake Forest Baptist Medical Center, Winston-Salem, North Carolina, USA*
- Poster #33**  
(p. ) **Computerized Navigation for Length and Rotation Control in Femoral Fractures: A Preliminary Clinical Study**  
**Yoram A. Weil, MD; Amal Khoury, MD; Alexander Greenberg, MD;**  
*Rami Mosheiff, MD; Meir Liebergall, MD;*  
*Department of Orthopedics, Hadassah Hebrew University Hospital,*  
*Jerusalem, Israel*
- Poster #34**  
(p. ) **Is it Safe to Place a Retrograde Femoral Intramedullary Nail Through a Traumatic Knee Arthrotomy?**  
*Jesse E. Bible, MD; Rishin J. Kadakia, BA; Ankeet A. Choxi, MD;*  
*Jennifer M. Bauer, MD; Hassan R. Mir, MD;*  
*Vanderbilt Orthopaedic Institute, Nashville, Tennessee, USA*
- Poster #35**  
(p. ) **Posterior Cruciate Ligament Injury With Retrograde Femoral Nailing: An Anatomic and MRI Study**  
*Joshua Blomberg, MD; Christopher J. Doro, MD;*  
*Department of Orthopaedics, University of Wisconsin School of Medicine,*  
*Madison, Wisconsin, USA*
- Poster #36**  
(p. ) **Femoral Version of the General Population: Does “Normal” Vary by Gender or Ethnicity?**  
**John D. Koerner, MD<sup>1</sup>; Neeraj M. Patel, MBS<sup>1</sup>; Richard S. Yoon, MD<sup>2</sup>;**  
*Michael S. Sirkin, MD<sup>1</sup>; Mark C. Reilly, MD<sup>1</sup>; Frank A. Liporace, MD<sup>1</sup>;*  
*<sup>1</sup>UMDNJ–New Jersey Medical School, Department of Orthopaedic Surgery,*  
*Newark, New Jersey, USA;*  
*<sup>2</sup>NYU–Hospital for Joint Diseases, Department of Orthopaedic Surgery,*  
*New York, New York, USA*
- FOOT/ANKLE/PILON**
- Poster #37**  
(p. ) **Entrapped Posteromedial Structures in Pilon Fractures**  
**Jonathan G. Eastman, MD; Reza Firoozabadi, MD, MA;**  
*Steven K. Benirschke, MD; David P. Barei, MD, FRCSC; Robert P. Dunbar, MD;*  
*Harborview Medical Center, Seattle, Washington, USA*

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- Poster #38**  
(p. )  
**Posterior Bone Loss as a Surrogate for Articular Injury in Supination External Rotation (SER) Ankle Fractures**  
*Milton T.M. Little, MD; Marshall B. Berkes, MD; Lionel E. Lazaro, MD; Peter K. Sculco, MD; Rachel M. Cymerman, BA; Nadine C. Pardee, BS; David L. Helfet, MD; Dean G. Lorich, MD; Hospital for Special Surgery/New York Presbyterian Hospital-Cornell, New York, New York, USA*
- Poster #39**  
(p. )  
**Intramedullary Nailing of AO/OTA Type 43C Distal Tibia Fractures**  
*Matthew S. Marcus, MD<sup>1</sup>; Frank A. Liporace, MD<sup>2</sup>; Richard S. Yoon, MD<sup>3</sup>; Kenneth J. Koval, MD<sup>4</sup>; George Haidukewych, DO<sup>4</sup>; Joshua Langford, MD<sup>4</sup>; <sup>1</sup>Jersey City, New Jersey, USA; <sup>2</sup>UMJNJ, Newark, New Jersey, USA; <sup>3</sup>NYU Hospital for Joint Diseases, New York, New York, USA <sup>4</sup>Orlando Health, Orlando, Florida, USA*
- Poster #40**  
(p. )  
**Surgical Treatment of Nonunion Following Rotational Ankle Fractures**  
*Sonya Khurana, BS; Raj Karia, MPH; Jordanna M. Forman, BS; Kenneth A. Egol, MD; NYU Hospital for Joint Diseases, New York, New York, USA*
- Poster #41**  
(p. )  
**Do Foot Fasciotomies Really Prevent Neuropathic Pain and Deformity?**  
*CPT Katherine M. Bedigrew, MD; CPT Daniel J. Stinner, MD; COL John F. Kragh, Jr., MD; MAJ Benjamin K. Potter, MD; LTC Scott B. Shaven, MD; LTC Joseph R. Hsu, MD, LTC, MC; Skeletal Trauma Research Consortium (STReC); San Antonio Military Medical Center, Fort Sam Houston, Texas, USA; Walter Reed Army Medical Center, Washington, District of Columbia, USA*
- Poster #42**  
(p. )  
**Sustentaculum Screw Placement During Calcaneal Open Reduction and Internal Fixation: When Is the Screw Out?**  
*Ida L. Gitajn, MD; R. James Toussaint, MD; John Y. Kwon, MD; Massachusetts General Hospital, Boston, Massachusetts, USA*
- Poster #43**  
(p. )  
**Predictive Factors of Hospital Length of Stay in Patients With Surgically Treated Ankle Fractures**  
*Matthew R. McDonald, BS; Jesse Ehrenfeld, MD, MPH; Khensani Marolen, MPH; A. Alex Jahangir, MD; William T. Obremskey, MD, MPH; Manish K. Sethi, MD; Vanderbilt University Medical Center, Nashville, Tennessee, USA*
- Poster #44**  
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**Return to Duty of Special Operations Command Personnel After Limb Salvage for High-Energy Lower Extremity Trauma**  
*Jeanne Cameron Patzkowski, MD, CPT, MC, USA; Johnny G. Owens, MPT; Ryan V. Blanck, LCPO; Joseph R. Hsu, MD, LTC, MC; Skeletal Trauma Research Consortium (STReC); San Antonio Military Medical Center, Fort Sam Houston, Texas, USA*

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## SCIENTIFIC POSTERS

- Poster #45**  
(p. )  
**Three-Dimensional, Digital, and Gross Anatomy of the Lisfranc Ligament**  
*Vinod K. Panchbhavi, MD; Domingo Molina IV, BS; Jaime Villarreal, BS; Michael C. Curry, MD; Clark R. Andersen, MS; Department of Orthopaedic Surgery and Rehabilitation, University of Texas Medical Branch, Galveston, Texas, USA*
- Poster #46**  
(p. )  
**Accuracy and Reliability of Bohler's Angle Measurements With Oblique Lateral Radiographs Taken in the Trauma Setting**  
*R. James Toussaint, MD; Ida L. Gitajn, MD; John Y. Kwon, MD; Massachusetts General Hospital, Boston, Massachusetts, USA*
- Poster #47**  
(p. )  
**Peroneal Tendon Dislocation Associated With Intra-Articular Calcaneus Fractures: An Underappreciated Problem**  
*R. James Toussaint, MD<sup>1</sup>; Darius Lin, MD<sup>1</sup>; Lauren K. Ehrlichman, MD<sup>1</sup>; Seenu Susarla, MD, DMD<sup>1</sup>; J. Kent Ellington, MD, MS<sup>2</sup>; Nicholas Strasser, MD<sup>2</sup>; John Y. Kwon, MD<sup>1</sup>; <sup>1</sup>Massachusetts General Hospital, Boston, Massachusetts, USA; <sup>2</sup>Carolinas Medical Center, Charlotte, North Carolina, USA*
- Poster #48**  
(p. )  
**Functional Outcomes of Supination External Rotation Type IV Ankle Fracture-Dislocations**  
*Peter K. Sculco, MD; Lionel E. Lazaro, MD; Milton M.T. Little, MD; Marshall B. Berkes, MD; David L. Helfet, MD; Dean G. Lorich, MD; Hospital for Special Surgery, New York, New York, USA*
- Poster #49**  
(p. )  
**CT Analysis of Medial Cuneiform Density**  
*Nick Boutris, BS; Karan A. Patel, BS; Domingo Molina, IV; Clark R. Andersen, BS; Vinod K. Panchbhavi, MD; University of Texas–Medical Branch, Galveston, Texas, USA*
- Poster #50**  
(p. )  
**The Role of Preoperative CT Scans in Operative Planning and Fixation of Malleolar Ankle Fractures**  
*E. M. Black; V. Antoci; J. T. Lee; M. J. Weaver; A. H. Johnson; S. M. Susarla; John Y. Kwon; Massachusetts General Hospital and Brigham and Women's Hospital, Boston, Massachusetts, USA*
- Poster #51**  
(p. )  
**Pie-Crusting Reduces Skin Tension During Suture Closure of Open Wounds: A Cadaveric Animal Study**  
*Gregory J. Della Rocca, MD, PhD, FACS; Adam C. Crawford, MD; Tyler A. Dailey, BS; Brett D. Crist, MD, MD; James P. Stannard, MD; David A. Volgas, MD; Ferris M. Pfeiffer, PhD; University of Missouri, Columbia, Missouri, USA*
- Poster #52**  
(p. )  
**Clinical and Functional Outcomes of Patients Undergoing Anterolateral Versus Anteromedial Surgical Approaches for Pilon Fractures**  
*Brett D. Crist, MD; Tyler Jenkins; Michael S. Khazzam, MD; Yvonne M. Murtha, MD; Gregory J. Della Rocca, MD, PhD; University of Missouri, Columbia, Missouri, USA*

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- Poster #53**  
(p. )
- Evaluation of the Reduction and Fixation of Calcaneus Fractures: A Delphi Consensus**  
*M.S.H. Beerekamp<sup>1</sup>; J.S.K. Luitse<sup>1</sup>; M. Maas<sup>2</sup>; D. Ubbink<sup>3</sup>; N.W.L. Schep<sup>1</sup>; J. Carel Goslings, MD, PhD<sup>1</sup>;*  
*<sup>1</sup>Trauma Unit, Department of Surgery, Academic Medical Center, Amsterdam, The Netherlands;*  
*<sup>2</sup>Department of Radiology, Academic Medical Center, Amsterdam, The Netherlands;*  
*<sup>3</sup>Department of Quality and Process Innovations, Academic Medical Center, Amsterdam, The Netherlands*
- Poster #54**  
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- A Clinical Evaluation of Alternative Fixation Techniques for Medial Malleolus Fractures**  
*Hayley Barnes, BS; Lisa K. Cannada, MD; J. Tracy Watson, MD;*  
*Saint Louis University Medical Center, Saint Louis, Missouri, USA*
- Poster #55**  
(p. )
- CAM Walkers Only Diminish Lower-Extremity Loading in a Clinically Meaningful Way During Dynamic Loading**  
*Kylee North; Ami R. Stuart, PhD; Thomas F. Higgins, MD;*  
*Robert W. Hitchcock, PhD; Erik N. Kubiak, MD;*  
*University of Utah, Salt Lake City, Utah, USA*
- Poster #56**  
(p. )
- Computed Tomography Assessment of Articular Reduction in Supination External Rotation Type IV (SER IV) Ankle Fractures**  
*Milton T.M. Little, MD; Marschall B. Berkes, MD; Lionel E. Lazaro, MD;*  
*Peter K. Sculco, MD; Rachel M. Cymerman, BA; Nadine C. Pardee, BS;*  
*David L. Helfet, MD; Dean G. Lorich, MD;*  
*Hospital for Special Surgery/New York Presbyterian Hospital–Cornell, New York, New York, USA*
- Poster #57**  
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- The Changing Epidemiology of Open Ankle Fractures**  
*Kate E. Bugler, MD; Nicholas D. Clement, MBBS; Timothy O. White, MD;*  
*Margaret M. McQueen, MD; Charles M. Court-Brown, MD;*  
*Orthopaedic Trauma Unit, Royal Infirmary Edinburgh,*  
*Edinburgh, Scotland, United Kingdom*
- PELVIS/ACETABULUM**
- Poster #58**  
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- Quantification of Bony Pelvic Exposure Through the Modified Stoppa Approach**  
*Jesse E. Bible, MD; Ankeet A. Choxi, BE; Rishin J. Kadakia, BA;*  
*Jason M. Evans, MD; Hassan R. Mir, MD;*  
*Vanderbilt Orthopaedic Institute, Nashville, Tennessee, USA*

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- Poster #59**  
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- Anterior Pelvic Morphology: Implications for Medullary Ramus Fixation**  
*Raymond D. Wright, Jr., MD<sup>1</sup>; David A. Hamilton, Jr., MD, MBA<sup>1</sup>; Milton L. Routt, Jr., MD<sup>2</sup>;*  
<sup>1</sup>Chandler Medical Center, University of Kentucky, Department of Orthopaedic Surgery and Sports Medicine, Lexington, Kentucky, USA;  
<sup>2</sup>Harborview Medical Center, University of Washington, Department of Orthopaedics and Sports Medicine, Seattle, Washington, USA
- Poster #60**  
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- Reliability of Qualitative Radiographic Characteristics of Upper Sacral Segment Dysmorphism**  
*Scott P. Kaiser, MD<sup>1</sup>; Michael J. Gardner, MD<sup>2</sup>; Joseph Liu, MD<sup>1</sup>; Milton L. Routt Jr., MD<sup>3</sup>; Saam Morshed, MD, MPH<sup>1</sup>;*  
<sup>1</sup>University of California San Francisco, San Francisco, California, USA;  
<sup>2</sup>Washington University School of Medicine, Saint Louis, Missouri, USA;  
<sup>3</sup>University of Washington, Seattle, Washington, USA
- Poster #61**  
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- Computed Tomographic Measurement of Pelvic Landmarks in Minimally Displaced Lateral Compression Sacral Fractures: Comparison to Radiographic Measurements**  
*John Lien, MD<sup>1</sup>; John Lee, MD<sup>1</sup>; Joseph Maratt, MD<sup>1</sup>; Sven Holcombe, MS<sup>1</sup>; Stewart Wang MD, PhD<sup>1</sup>; Paul Tornetta, III, MD<sup>2</sup>; James Goulet MD<sup>1</sup>;*  
<sup>1</sup>University of Michigan Health System, Ann Arbor, Michigan, USA;  
<sup>2</sup>Boston Medical Center, Boston, Massachusetts, USA
- Poster #62**  
(p. )
- Δ Biomechanical Mechanisms Underlying Preferential Peroneal Nerve Injury Following Acetabular Fracture and Surgery**  
*Kanu Goyal, MD<sup>1</sup>; Michael Hill, PhD<sup>1</sup>; Hans-Christoph Pape, MD, MD<sup>1</sup>; John Moossy, MD<sup>2</sup>; Ivan S. Tarkin, MD<sup>1</sup>;*  
<sup>1</sup>Department of Orthopaedic Surgery, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, USA;  
<sup>2</sup>Department of Neurosurgery, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, USA
- Poster #63**  
(p. )
- Reliability of Radiographic Measurement Techniques in Pelvic Ring Disruptions**  
*Kelly A. Lefaiore, MD<sup>1</sup>; Piotr A. Blachut, MD<sup>1</sup>; Adam J. Starr, MD<sup>2</sup>; Gerard S. Slobogean, MD, MPH<sup>1</sup>; Peter J. O'Brien, MD<sup>1</sup>;*  
<sup>1</sup>University of British Columbia, Vancouver, British Columbia, Canada;  
<sup>2</sup>University of Texas Southwestern, Dallas, Texas, USA
- Poster #64**  
(p. )
- Correlation of Acetabular Dysplasia With Hip Dislocation and Hip Fracture-Dislocations**  
*Kyle T. Judd, MD; Jason M. Evans, MD;*  
Vanderbilt University Medical Center, Nashville, Tennessee, USA

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**Δ Nerve Microstructure and Composition Underlying Preferential Peroneal Nerve Injury After Acetabular Fracture and Surgery**  
*Kanu Goyal, MD<sup>1</sup>, Sean Flynn, BS<sup>1</sup>; Michael Hill, PhD<sup>1</sup>;  
Hans-Christoph Pape, MD<sup>1</sup>; John Moossy, MD<sup>2</sup>; Ivan S. Tarkin, MD<sup>1</sup>;  
<sup>1</sup>Department of Orthopaedic Surgery, University of Pittsburgh Medical Center,  
Pittsburgh, Pennsylvania, USA;  
<sup>2</sup>Department of Neurosurgery, University of Pittsburgh Medical Center,  
Pittsburgh, Pennsylvania, USA*

**Poster #66**  
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**Pelvic CT-Based Modeling for Placement of Safe Transsacral Screws and Identification of Sacral Dysmorphism**  
*Soham Banerjee, BS; Adam J. Starr, MD; Rahul Banerjee, MD;  
UT Southwestern Medical Center, Dallas, Texas, USA*

**Poster #67**  
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**Clinical and Economic Impact of Generic 7.3mm Cannulated Sacroiliac Screws**  
*Justin R. Kauk, MD<sup>1</sup>; Peter L. Althausen, MD<sup>1</sup>, MBA;  
Daniel J. Coll, MHS, PA-C<sup>2</sup>; Timothy J. O'Mara, MD<sup>1</sup>; Timothy J. Bray, MD<sup>1</sup>;  
<sup>1</sup>Reno Orthopaedic Clinic, Reno, Nevada, USA;  
<sup>2</sup>Renown Regional Medical Center, Reno, Nevada, USA*

**Poster #68**  
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**Combat-Related Hemipelvectomy: Eleven Cases, A Review of the Literature, and Lessons Learned**  
*Jean-Claude G. D'Alleyrand, MD<sup>1,2</sup>; Mark Fleming, DO<sup>1,2</sup>;  
Wade T. Gordon, MD<sup>1,2</sup>; LTC Romney C. Andersen, MD, MC, USN<sup>1,2</sup>;  
Brian Mullis, MD<sup>1</sup>; Benjamin K. Potter, MD<sup>1,2</sup>;  
<sup>1</sup>Integrated Department of Orthopaedics and Rehabilitation,  
Walter Reed National Military Medical Center, Bethesda, Maryland, USA;  
<sup>2</sup>Norman M. Rich Department of Surgery, Uniformed Services University of  
Health Sciences, Bethesda, Maryland, USA*

**Poster #69**  
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**• Biomechanical Evaluation of a Percutaneous Fixation System for the Treatment of Unstable Posterior Pelvic Ring Injuries**  
*Jonathan Vigdorichik, MD<sup>1</sup>; Amanda O. Esquivel, PhD<sup>1</sup>; Xin Jin, PhD<sup>2</sup>;  
King H. Yang, PhD<sup>2</sup>; Darren T. Herzog, MD<sup>1</sup>; Bryant W. Oliphant, MD<sup>1</sup>;  
Rahul Vaidya, MD<sup>1</sup>;  
<sup>1</sup>Detroit Receiving Hospital/Detroit Medical Center, Detroit, Michigan, USA;  
<sup>2</sup>Wayne State University Department of Biomedical Engineering,  
Detroit, Michigan, USA*

**Poster #70**  
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**A Prospective Randomized Comparison of Two Skin Closure Methods in Acetabular Fracture Surgery**  
*Christopher D. Mudd, MD; John A. Boudreau, MD; Berton R. Moed, MD;  
Saint Louis University School of Medicine, Saint Louis, Missouri, USA*

**Poster #71**  
(p. )

**Early Failure of Symphysis Pubis Plating: Analysis of Injury and Fixation Factors**  
*Jonathan G. Eastman, MD; James C. Krieg, MD; Milton L. Routt, Jr., MD;  
Harborview Medical Center, Seattle, Washington, USA*

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- Poster #72**  
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**Defining the Spectrum of APC II Pelvic Fractures: A Radiographic Assessment of 42 Consecutive Cases**  
*Brian M. Tonne, MD; Laurence B. Kempton, MD; Madhav A. Karunakar, MD; Carolinas Medical Center, Charlotte, North Carolina, USA*
- Poster #73**  
(p. )  
**Examination Under Anesthesia for Posterior Wall Acetabular Fracture: A Survey of the OTA Membership**  
*John Riehl, MD; Kenneth J. Koval, MD; Joshua Langford, MD; Mark W. Munro, MD; George J. Haidukewych, MD; Orlando Regional Medical Center, Orlando, Florida, USA*
- Poster #74**  
(p. )  
**Cadaver Pelvic Biomechanical Study: Locked Versus Standard Unlocked Plating of the Symphysis Pubis in a Type C Pelvic Injury Model**  
*Christopher P. O'Boynick, MD; Gary Bledsoe, PhD; Berton R. Moed, MD; Saint Louis University School of Medicine, Saint Louis, Missouri, USA*
- Poster #75**  
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**Risk Factors for the Development of Severe Heterotopic Ossification Following Acetabular Fracture Surgery**  
*Harris S. Slone, MD; Zeke J. Walton, MD; Charles A. Daly, BS; Russell W. Chapin, MD; William R. Barfield, PhD; Lee R. Leddy, MD; Langdon A. Hartsock, MD; Medical University of South Carolina, Charleston, South Carolina, USA*
- Poster #76**  
(p. )  
**Open Pelvic Ring Fractures: What Are the Risk Factors for Mortality and Infection?**  
*Julie Taylor, BS; Robert V. O'Toole, MD; Theodore T. Manson, MD; R Adams Cowley Shock Trauma Center, Department of Orthopaedics, University of Maryland School of Medicine, Baltimore, Maryland, USA*
- FEMUR/KNEE/TIBIA**
- Poster #77**  
(p. )  
**Quantitative and Qualitative Assessment of Bone Perfusion and Vascularity in Patellar Fractures Using Gadolinium-Enhanced MRI**  
*Lionel E. Lazaro, MD<sup>1</sup>; David S. Wellman, MD<sup>1</sup>; Peter K. Sculco, MD<sup>1</sup>; Craig E. Klinger, BS<sup>1</sup>; Jonathan Dyke, PhD<sup>2</sup>; Nadine C. Pardee, BS<sup>1</sup>; Thomas W. Axelrad<sup>1</sup>, MD; Marschall B. Berkes<sup>1</sup>, MD; Michael B. Cross<sup>1</sup>, MD; David L. Helfet, MD<sup>1</sup>; Dean G. Lorch, MD<sup>1</sup>;  
<sup>1</sup>Hospital for Special Surgery and Weill Medical College of Cornell University, New York, New York, USA;  
<sup>2</sup>Citigroup Biomedical Imaging Center, Weill Medical College of Cornell University, New York, New York, USA*
- Poster #78**  
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**CT Scan Improves Classification and Management of Open Fractures About the Knee Compared to Plain Radiographs in Patients Presenting to the Emergency Department With a Periarticular Knee Wound**  
*Sanjit R. Konda, MD; Daniel Howard, BS; Roy I. Davidovitch, MD; Kenneth A. Egol, MD; NYU Hospital for Joint Disease, New York, New York, USA*

- Poster #79**  
(p. )  
**Tibial Plateau Fractures With and Without Mensicus Tear: Results of a Standardized Treatment Protocol**  
*Jordanna Forman, BS; Raj Karia, MPH; Roy I. Davidovitch, MD; Kenneth A. Egol, MD;*  
*NYU Hospital for Joint Diseases, New York, New York, USA*
- Poster #80**  
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**CT Scan to Detect Traumatic Arthrotomies via Intra-Articular Air in the Knee Joint: A Cadaver Study to Define a Low Radiation Dose Imaging Protocol**  
*Sanjit R. Konda, MD; Daniel Howard, BS; Soterios Gyftopoulos, MD; Roy I. Davidovitch, MD; Kenneth A. Egol, MD;*  
*NYU Hospital for Joint Disease, New York, New York, USA*
- Poster #81**  
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**Knee Arthroplasty Following Tibial Plateau Fracture**  
*Matthew T. Houdek, MD<sup>1</sup>; Jordan Smith, MD<sup>2</sup>; William Grana, MD<sup>2</sup>;*  
*John T. Ruth MD<sup>2</sup>;*  
*<sup>1</sup>Mayo Clinic Department of Orthopedic Surgery, Rochester, Minnesota, USA;*  
*<sup>2</sup>University of Arizona Health Network, Tucson, Arizona, USA*
- Poster #82**  
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**The Use of Calcium Phosphate Bone Cement in Tibial Plateau Fractures: A Systematic Review and Meta-Analysis**  
*Sara C. Graves, MD; Yulin Hswen; John Naslund; Natalie Riblet;*  
*Robert V. Cantu, MD; Alexander O. Orem, MD;*  
*Dartmouth Hitchcock Medical Center, Lebanon, New Hampshire, USA*
- Poster #83**  
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**The Saline Load Test Redefined: A Test to Detect Traumatic Arthrotomies and Rule Out Periarticular Wounds Equivalent to No Traumatic Arthrotomy of the Knee**  
*Sanjit R. Konda, MD; Roy I. Davidovitch, MD; Kenneth A. Egol, MD;*  
*NYU Hospital for Joint Disease, New York, New York, USA*
- Poster #84**  
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**Tibial Plateau Fractures Treated With Structural Bone Grafts Experience Minimal Articular Subsidence and Good Clinical Outcomes**  
*Marschall B. Berkes, MD; Milton T. M. Little, MD; Patrick C. Schottel, MD;*  
*Nadine C. Pardee, BS; Aernout Zuiderbaan; Lionel E. Lazaro;*  
*Dean G. Lorich, MD; David L. Helfet, MD;*  
*Hospital for Special Surgery, New York, New York, USA*
- Poster #85**  
(p. )  
**Diagnostic Accuracy and Reproducibility of the Ottawa Knee Rule (OKR) Versus the Pittsburgh Decision Rule (PDR)**  
*Tung C. Cheung, MD; Robert J. Derksen, MD; Yeliz Tank, BS;*  
*Wim E. Tuinebreijer, MD; Roelf S. Breederveld, MD;*  
*Red Cross Hospital, Beverwijk, The Netherlands*
- Poster #86**  
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**A Modified Posterior Approach to the Knee for Posteromedial Tibial Plateau Fracture Fixation**  
*Reshid Berber, MBBS; Charlotte P. Lewis; Daren P. Forward, MD;*  
*Christopher G. Moran, MD;*  
*Queen's Medical Centre, Nottingham University Hospitals,*  
*Nottingham, United Kingdom*

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## SCIENTIFIC POSTERS

### UPPER EXTREMITY

Poster #87

(p. )

**Does Anteroinferior Fixation of Midshaft Clavicle Fractures Have a Lower Rate of Hardware Removal and Complications?**

**A Multicenter Retrospective Study**

*Peter A. Cole, MD<sup>1</sup>; Clifford B. Jones, MD, FACS<sup>2</sup>; Aaron R. Jacobson, DC<sup>1</sup>;*

*Alex Gilde, BS<sup>2</sup>; Jerald R. Westberg, BA<sup>3</sup>; Andrew H. Schmidt, MD<sup>3</sup>;*

*<sup>1</sup>University of Minnesota–Regions Hospital, St. Paul, Minnesota, USA;*

*<sup>2</sup>Michigan State University, Orthopaedic Associates of Michigan,*

*Grand Rapids, Michigan, USA;*

*<sup>3</sup>Hennepin County Medical Center, Minneapolis, Minnesota, USA*

Poster #88

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**Locked Bridge Plating is a Suitable Option for Forearm Fractures Secondary to Civilian Low-Velocity Gunshot Injuries**

*Rahul Vaidya, MD; Anil Sethi, MD; Bryant W. Oliphant, MD;*

*William Braaksma, MD; Nathan Rimmke, MD; Robert Colen, DO;*

*Detroit Receiving Hospital, Detroit, Michigan, USA*

Poster #89

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**Total Elbow Arthroplasty for Distal Humerus Fractures: Long-Term Outcomes**

*Philipp N. Streubel, MD; Juan P. Simone, MD; Bernard F. Morrey, MD;*

*Joaquin Sanchez-Sotelo, MD, PhD;*

*Mayo Clinic, Rochester, Minnesota, USA*

Poster #90

(p. )

**The Validation of a New Radiographic Union Score (RUS) for Distal Radius Fractures**

*Emil H. Schemitsch, MD<sup>1,2</sup>; Anthony Marchie<sup>1</sup>; Alfonse Marchie<sup>3</sup>;*

*Farid Guirguis<sup>4</sup>; Kevin Ho<sup>3</sup>; Martin Roscoe<sup>4</sup>; Amr ElMaraghy<sup>4</sup>;*

*Rad Zdero<sup>2,5</sup>;*

*<sup>1</sup>Division of Orthopaedic Surgery, University of Toronto,*

*Toronto, Ontario, Canada;*

*<sup>2</sup>Biomechanics Laboratory, St. Michael's Hospital, Toronto, Ontario, Canada;*

*<sup>3</sup>Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada;*

*<sup>4</sup>Division of Orthopaedic Surgery, St. Joseph's Health Centre,*

*Toronto, Ontario, Canada;*

*<sup>5</sup>Department of Mechanical and Industrial Engineering, Ryerson University,*

*Toronto, Ontario, Canada*

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**Exposure of the Distal Humerus Using a Triceps Hemi-Peel Approach**

*Brian F. Grogan, MD, CPT<sup>1</sup>; James A. Blair, MD, CPT<sup>1</sup>;*

*Robert E. Blease, MD, MAJ<sup>2</sup>; Mickey S. Cho, MD, LTC<sup>1</sup>;*

*Joseph R. Hsu, MD, LTC<sup>3</sup>;*

*<sup>1</sup>Department of Orthopedics and Rehabilitation, San Antonio Military Medical*

*Center (SAMMC), San Antonio Uniformed Services Health Education*

*Consortium (SAUSHEC), Fort Sam Houston, Texas, USA;*

*<sup>2</sup>United States Army Tropic Test Center/Ryder Trauma Center,*

*Miami, Florida, USA;*

*<sup>3</sup>US Army Institute of Surgical Research, San Antonio Military Medical Center*

*(SAMMC), San Antonio Uniformed Services Health Education Consortium*

*(SAUSHEC), Fort Sam Houston, Texas, USA*

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- Poster #92**  
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- Heterotopic Ossification in Open Periarticular Combat-Related Elbow Fractures**  
*LT Kevin W. Wilson, MD, MC, USN; CPT Jonathan F. Dickens, MD, MC; LT Scott M. Tintle, MD, MC, USN; LT Reed Heckert, MD, MC, USN; CDR John J. Keeling, MD, MC, USN; LTC Romney C. Andersen, MD, MC, USN; MAJ Benjamin K. Potter, MD, MC, USA*  
*Department of Orthopaedics and Rehabilitation, Walter Reed National Military Medical Center, Bethesda, Maryland, USA*
- Poster #93**  
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- Functional Outcomes Following Major Upper Limb Trauma in the Military**  
*The METALS Study Group; Brown University Department of Orthopaedic Surgery, Providence, Rhode Island, USA*
- Poster #94**  
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- Fractures of the Greater Tuberosity of the Humerus: A Retrospective Study on Function, Muscular Atrophy, and Fracture Morphology**  
*Jennifer Mutch, MD<sup>1</sup>; Luojun Wang<sup>2</sup>; George-Yves Laflamme, MD, FRCSC<sup>1</sup>; Nicola Hagemeister<sup>3</sup>; Dominique M. Rouleau, MD, MSc, FRCSC<sup>1</sup>;*  
*<sup>1</sup>Hôpital du Sacré-Cœur de Montréal, Université de Montréal, Montreal, Quebec, Canada;*  
*<sup>2</sup>Université de Montréal, Montreal, Quebec, Canada;*  
*<sup>3</sup>Centre Hospitalier de l'Université de Montréal, École de Technologie Supérieure, Montreal, Quebec, Canada*
- Poster #95**  
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- Fixation Utilizing an Endosteal Strut Augment Allows for Similar Outcomes Between Neer 2, 3, and 4-Part Proximal Humerus Fractures**  
*Marschall B. Berkes, MD; Milton T. M. Little, MD; Nadine C. Pardee, BS; Patrick C. Schottel, MD; Lauren E. Lamont, MD; Lionel E. Lazaro, MD; David L. Helfet, MD; Dean G. Lorich, MD;*  
*Hospital for Special Surgery, New York, New York, USA*
- Poster #96**  
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- Triple and Quadruple Disruptions of the Superior Shoulder Suspensory Complex**  
*Peter A. Cole, MD; Brett Mulawka, MS; Aaron R. Jacobson, DC;*  
*University of Minnesota, Minneapolis, Minnesota, USA*
- Poster #97**  
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- Socioeconomic Deprivation Predicts Outcome Following Radial Head and Neck Fractures**  
*Andrew D. Duckworth, MBChB, BSc (Hons); Nicholas D. Clement, MRCSd;*  
*Paul J. Jenkins, MRCSd; Elizabeth M. Will, MCSP;*  
*Charles M. Court-Brown, MD; Margaret M. McQueen, MD;*  
*Edinburgh Orthopaedic Trauma Unit, Royal Infirmary of Edinburgh, Edinburgh, Scotland, United Kingdom*

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- Poster #98**  
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- Impact of Radiographic Beam Position on the Radiocapitellum Ratio (RCR) in Healthy Elbows**  
*Emilie Sandman, MD<sup>1,2</sup>; Fannie McCann<sup>2</sup>; Fanny Canet, MScA<sup>1</sup>; Yvan Petit, PhD<sup>1,3</sup>; George-Yves Laflamme, MD, FRCSC<sup>1</sup>; Dominique M. Rouleau, MD, MSc, FRCSC<sup>1</sup>;*  
*<sup>1</sup>Hôpital du Sacré-Cœur de Montréal, Montreal, Quebec, Canada;*  
*<sup>2</sup>Université de Montréal, Montreal, Quebec, Canada;*  
*<sup>3</sup>École de Technologie Supérieure, Montreal, Quebec, Canada,*
- Poster #99**  
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- Plain Radiographs, CT, and Three-Dimensional Reconstruction: A Comparative Analysis of Measured Displacement for Isolated Greater Tuberosity Fractures of the Proximal Humerus**  
*Jennifer Mutch, MD<sup>1</sup>; Dominique M. Rouleau, MD, MSc, FRCSC<sup>1</sup>; George-Yves Laflamme, MD, FRCSC<sup>1</sup>; Nicola Hagemeister<sup>2</sup>;*  
*<sup>1</sup>Hôpital du Sacré-Cœur de Montréal, Université de Montréal, Montreal, Quebec, Canada;*  
*<sup>2</sup>Centre Hospitalier de l'Université de Montréal, École de Technologie Supérieure, Montreal, Quebec, Canada*
- Poster #100**  
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- Dorsal Radial Blind Spot**  
*Andrew K. Brown, MD; Howard Roth, MD; David A. Fuller, MD;*  
*Cooper University Medical Center, Camden, New Jersey, USA*
- Poster #101**  
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- Impaired Functional Outcome Associated With Perilunate Injuries of the Wrist**  
*Brandon J. Yuan, MD; Sanjeev Kakar, MD; David B. Jones, MD;*  
*Peter C. Rhee, MD; Steven L. Moran, MD;*  
*Department of Orthopedic Surgery, Mayo Clinic, Rochester, Minnesota, USA*
- Poster #102**  
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- Corrective Osteotomy for Combined Intra- and Extra-Articular Distal Radius Malunion**  
*Geert A. Buijze, MD<sup>1</sup>; Karl-Josef Prommersberger, MD<sup>2</sup>;*  
*Juan González del Pino, MD, PhD<sup>3</sup>; Diego L. Fernandez, MD<sup>4</sup>;*  
*Jesse B. Jupiter, MD<sup>1</sup>;*  
*<sup>1</sup>Massachusetts General Hospital, Boston, Massachusetts, USA;*  
*<sup>2</sup>Rhön-Klinikum, Bad Neustadt an der Saale, Germany;*  
*<sup>3</sup>Santa Cristina University Hospital, Madrid, Spain;*  
*<sup>4</sup>Lindenhof Hospital, Bern, Switzerland*
- Poster #103**  
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- Treatment of Acute Versus Chronic Proximal Row Carpal Injuries**  
*Eric R. Wagner, MD<sup>1</sup>; Robert R. Gray, MD<sup>2</sup>; Sanjeev Kakar, MD<sup>1</sup>;*  
*<sup>1</sup>Mayo Clinic, Rochester, Minnesota, USA;*  
*<sup>2</sup>University of Miami Health Systems, Miami, Florida, USA*
- Poster #104**  
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- External Fixation Versus Open Reduction With Plate Fixation for Distal Radius Fractures: A Meta-Analysis of Randomized Controlled Trials**  
*Paul R.T. Kuzyk, MSc, MD, FRCS(C); John Esposito, MD;*  
*Michel Saccone, BSc; Emil H. Schemitsch, MD, FRCS(C);*  
*Division of Orthopaedics, Department of Surgery, University of Toronto, Toronto, Ontario, Canada*

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- Poster #105**  
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- A Biomechanical Study of Distal Volar Radius Plates for the Treatment of Distal Radius Osteotomies: Are they Able to Withstand Cyclic Physiologic Loads Thus Allowing Early Active Range of Motion?**  
*Alexandra C.R. Stratton, MD; Amy Hsiao, PhD; Andrew Furey, MD; Craig Stone, MD; Chris Hamilton, MD;*  
*Health Sciences Center, Memorial University of Newfoundland, St. Johns, Newfoundland, Canada*
- Poster #106**  
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- Does Patient Willingness to Randomize to Treatment Affect Self-Reported Satisfaction After Distal Radius Fracture?**  
*Kenneth J. Koval, MD<sup>1</sup>; Kevin F. Spratt, PhD<sup>2</sup>;*  
*<sup>1</sup>Orlando Regional Medical Center, Orlando, Florida, USA;*  
*<sup>2</sup>Department of Orthopaedic Surgery, Dartmouth Medical Center, Lebanon, New Hampshire, USA*
- Poster #107**  
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- Predictors of Nonunion Following a Fracture of the Scaphoid**  
*Andrew D. Duckworth, MBChB,BSc (Hons); Kate E. Bugler, MRCSed;*  
*Nicholas D. Clement, MRCSed; Stuart A. Aitken;*  
*Margaret M. McQueen, MD;*  
*Edinburgh Orthopaedic Trauma Unit, Royal Infirmary of Edinburgh, Edinburgh, Scotland, United Kingdom*
- Poster #108**  
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- A Novel, Multiplanar and Less-Invasive Approach to Distal Radius Fracture Fixation: A Prospective Case Series**  
*Michael Strassmair, MD<sup>1</sup>; Daniel R. Rikli<sup>2</sup>; Jörg Schmidt, MD<sup>3</sup>;*  
*Hand-Josef Erli, MD<sup>4</sup>; Joseph Hale<sup>5</sup>; Andrew H. Schmidt, MD<sup>6</sup>;*  
*Thomas M. Walsh, MD<sup>7</sup>; Steven L. Moran<sup>8</sup>;*  
*<sup>1</sup>Klinikum Starnberg, Starnberg Germany;*  
*<sup>2</sup>Universitätsspital Basel, Basel, Switzerland;*  
*<sup>3</sup>Weissenfels, Berlin, Germany;*  
*<sup>4</sup>Vivantes Humboldt Klinikum, Berlin, Germany;*  
*<sup>5</sup>Conventus Orthopaedics, Maple Grove, Minnesota, USA;*  
*<sup>6</sup>Hennepin County Medical Center, Minneapolis, Minnesota, USA;*  
*<sup>7</sup>Park Nicollet Health Services, Minneapolis, Minnesota, USA;*  
*<sup>8</sup>Mayo Clinic, Rochester, Minnesota, USA*
- GENERAL**
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- The Relationship Between Length of Stay and ASA Class in the Surgical Treatment of the Orthopaedic Trauma Patient**  
*Zachary Yoneda, BS; A. Alex Jahangir, MD; Jesse Ehrenfeld, MD, MPH;*  
*Mallory Powell, BA; William T. Obremskey, MD, MPH; Manish K. Sethi, MD;*  
*Vanderbilt University Medical Center, Nashville, Tennessee, USA*
- Poster #110**  
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- Implementation of Usage Guidelines for Bone Graft Products Reduces Costs**  
*Megan A. Brady, MD; Heather A. Vallier, MD; John H. Wilber, MD;*  
*MetroHealth Medical Center, Cleveland, Ohio, USA*

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- Poster #111**  
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- Massachusetts Health Care Reform: Its Effect on the Percentage of Uninsured Patients and the Reimbursement for Provider Services at Academic Urban Level I Trauma Centers**  
*R. James Toussaint, MD<sup>1</sup>; Michael J. Weaver, MD<sup>1</sup>; Paul Tornetta, III, MD<sup>2</sup>; Mark S. Vrahas, MD<sup>1</sup>; Mitchel B. Harris, MD<sup>1</sup>;*  
*<sup>1</sup>Brigham and Women's Hospital, Boston, Massachusetts, USA;*  
*<sup>2</sup>Boston Medical Center, Boston, Massachusetts, USA*
- Poster #112**  
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- What Macroeconomic Factors Affect Orthopaedic Trauma Volume?**  
*David A. Hamilton, MD, MBA; Daniel L. Davenport, PhD, MBA;*  
*Jeffrey B. Selby, MD; Eric S. Moghadamian, MD; Brandon T. Bruce, MD;*  
*Raymond D. Wright, MD;*  
*University of Kentucky Department of Orthopaedic Surgery,*  
*Lexington, Kentucky, USA*
- Poster #113**  
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- Are Orthopaedic Trauma Jobs Scarce?**  
*William T. Obremeskey, MD, MPH<sup>1</sup>; Kyle Judd, MD<sup>1</sup>; Lisa K. Cannada, MD<sup>2</sup>;*  
*<sup>1</sup>Vanderbilt University Medical Center, Nashville, Tennessee, USA*  
*<sup>2</sup>Saint Louis University, Saint Louis, Missouri, USA*
- Poster #114**  
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- Orthopaedic Trauma Surgeons' Compliance with OTA Meeting Poster Guidelines**  
*Meir Marmor, MD; Amir M. Matityahu, MD;*  
*Orthopaedic Trauma Institute, San Francisco General Hospital,*  
*University of California San Francisco, San Francisco, California, USA*
- Poster #115**  
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- Does a Dedicated Geriatrics Service Improve Outcomes and Decrease Length of Stay for Nonagenarians With Operatively Treated Hip Fractures?**  
*Abbey Gore, MD; James N. DeBritz, MD; Robert D. Golden, MD;*  
*MedStar Washington Hospital Center, Washington, District of Columbia, USA*
- Poster #116**  
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- Health Literacy in an Orthopaedic Trauma Patient Population: Improving Patient Comprehension With Informational Intervention**  
*James M. Tsahakis, BA; Neil M. Issar, BSc; Rishin J. Kadakia, BSc;*  
*Kristin R. Archer, PhD, DPT; Tisha Barzyk, MSN, RN, ACNP-BD;*  
*Hassan R. Mir, MD;*  
*Vanderbilt University Medical Center, Nashville, Tennessee, USA*
- Poster #117**  
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- Can It Wait Until Morning? A Meta-Analysis of the Six-Hour Rule of Open Fracture Management**  
*Mara L. Schenker, MD; Sarah Yannascoli, MD; Keith Baldwin, MD;*  
*Jaimo Ahn; Samir Mehta, MD;*  
*Department of Orthopaedic Surgery, University of Pennsylvania,*  
*Philadelphia, Pennsylvania, USA*

- Poster #118**  
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- Profile of Litigation for Trauma-Related Cases Within the National Health System in the United Kingdom**  
*Stelios Theocharakis<sup>1</sup>; A. B. McWilliams<sup>2</sup>; Kostas Makridis<sup>1</sup>; Martin H. Stone<sup>2</sup>; Nikolaos K. Kanakaris, MD<sup>1</sup>; Peter V. Giannoudis, MD<sup>1</sup>; <sup>1</sup>Academic Department of Trauma and Orthopaedics, Leeds Teaching Hospitals, Leeds, United Kingdom; <sup>2</sup>Leeds Musculoskeletal Biomedical Research Unit, Chapel Allerton Hospital, Leeds, United Kingdom*
- Poster #119**  
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- “Apples to Apples”: Moving to the New OTA Fracture Severity Classification in Extremity Trauma Research**  
*Major Extremity Trauma Research Consortium (METRC); Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA*
- Poster #120**  
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- The Musculoskeletal Function Assessment: Establishing Normative Data**  
*Jessica C. McMichael, MD; Berton R. Moed, MD; Heidi Israel, PhD; Saint Louis University, Saint Louis, Missouri, USA*
- Poster #121**  
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- Identifying Enrollment Challenges and Discovering Research Opportunities in an Orthopaedic Trauma Consortium: The Value of a “Start-up” Registry**  
*Major Extremity Trauma Research Consortium (METRC); Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA*
- Poster #122**  
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- Δ Development of a Multidimensional Postoperative Pain Tool for Orthopaedic Trauma Surgery**  
*Kristin R. Archer, PhD<sup>1</sup>; Renan C. Castillo, PhD<sup>2</sup>; Christine M. Abraham, MA<sup>1</sup> Sara E. Heins<sup>2</sup>; Yanna Song, MS<sup>1</sup>; Stephen T. Wegener, PhD<sup>3</sup>; William T. Obremskey, MD, MPH<sup>1</sup>; <sup>1</sup>Vanderbilt University Medical Center, Nashville, Tennessee, USA; <sup>2</sup>Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA; <sup>3</sup>Johns Hopkins Medicine, Baltimore, Maryland, USA*
- Poster #123**  
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- Factors Affecting Pain in Acute Ankle Fractures: A Prospective Evaluation**  
*David Saper, MD; Jody Litrenta, MD; Peters Otlans, MPH; James Daley, MPH; Paul Tornetta, III, MD; Boston University Medical Center, Boston, Massachusetts, USA*
- Poster #124**  
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- The Orthopaedic Trauma Patient: Risk Factors Influencing Follow-up**  
*Vignesh K. Almanda, BS; Barry Kang, BS; Jesse Ehrenfeld, MD, MPH; William T. Obremskey, MD, MPH; Zachary Yoneda BS; Manish K. Sethi, MD; A. Alex Jahangir, MD; Vanderbilt University Medical Center, Nashville, Tennessee, USA*

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**Reliability of an Adaptive Computer-Based Patient Outcomes Scoring Tool in Orthopaedic Trauma Patients**  
*Brett D. Crist, MD; Gregory J. Della Rocca, MD, PhD; David A. Volgas, MD; James P. Stannard, MD; University of Missouri, Columbia, Missouri, USA*
- Poster #126**  
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**A Prospective Randomized Double-Blind Control Trial Assessing Patient Satisfaction in an Orthopaedic Trauma Population**  
*Brent Morris, MD; Justin Richards, MD; Melissa Lasater, MSN, ACNP; Denise Rabalais, BA; Cindy Wedel, MPA; Ronald W. Hill, MPH; Manish K. Sethi, MD; A. Alex Jahangir, MD; Vanderbilt University Medical Center, Nashville, Tennessee, USA*
- Poster #127**  
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**Is Patient Satisfaction Among Orthopaedic Trauma Patients Predicted by Patient Depression and Activation?**  
*Elisa J. Knutsen, MD<sup>1</sup>; Ebrahim Paryavi, MD, MPH<sup>1</sup>; Renan C. Castillo, PhD<sup>2</sup>; Robert V. O'Toole, MD<sup>1</sup>;*  
*<sup>1</sup>R Adams Cowley Shock Trauma Center, Department of Orthopaedics, University of Maryland School of Medicine, Baltimore, Maryland, USA;*  
*<sup>2</sup>Center for Injury Research & Policy, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA*
- Poster #128**  
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**The Prevalence and Costs of Defensive Medicine Among Orthopaedic Trauma Surgeons: A National Survey Study**  
*Manish K. Sethi, MD; Vasanth Sathiyakumar, BS; William T. Obremsky, MD, MPH; Hassan R. Mir, MD; A. Alex Jahangir, MD; Vanderbilt University Medical Center; Nashville, Tennessee, USA*
- Poster #129**  
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**The Homeless Orthopaedic Trauma Patient: Issues With Follow-up**  
*Vasanth Sathiyakumar, BS; Jake J. Porter III, MPH; Adedapo Ajayi, BS; William T. Obremsky, MD, MPH; Jesse Ehrenfeld, MD, MPH; Mallory Powell, BA; A. Alex Jahangir, MD; Manish K. Sethi, MD; Vanderbilt University Medical Center, Nashville, Tennessee, USA*
- Poster #130**  
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**Can External Fixators Be Sterilized for Surgery? A Prospective Cohort Study in Orthopaedic Trauma Patients**  
*David Hardski, MD<sup>1</sup>; Richard Venezia, MD<sup>2</sup>; Jason W. Nascone, MD<sup>1</sup>; Marcus F. Sciadini, MD<sup>1</sup>; Robert V. O'Toole MD<sup>1</sup>;*  
*<sup>1</sup>R A Cowley Shock Trauma Center, Department of Orthopaedics, University of Maryland School of Medicine, Baltimore, Maryland, USA;*  
*<sup>2</sup>University of Maryland Medical Center, Baltimore, Maryland, USA*
- Poster #131**  
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**Do Smokers Know Smoking Is Bad for Fracture Healing?**  
*Paul E. Matuszewski, MD; Robert V. O'Toole, MD; Christina L. Boulton, MD; R Adams Cowley Shock Trauma Center, Department of Orthopaedics, University of Maryland School of Medicine, Baltimore, Maryland, USA*

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- Poster #132**  
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**Predictors of Need for In-Patient Rehabilitation Post Surgery for Lower Extremity Injury (RADI Pilot Project)**  
*Dominique Rouleau, MD, FRCSC, MSc<sup>1</sup>; Alexandre Place, BSc<sup>2</sup>; George-Yves Laflamme, MD, FRCSC<sup>1</sup>; Debbie Feldman, PhD<sup>2</sup>; <sup>1</sup>Hôpital du Sacré-Coeur de Montréal, Université de Montréal, Montreal, Quebec, Canada; <sup>2</sup>Université de Montréal, Montreal, Quebec, Canada*
- Poster #133**  
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**A Ten-Year Analysis of the Orthopaedic Trauma Association Research Funding Program**  
*Mitchell Bernstein, MD<sup>1</sup>; Nicholas M. Desy, MD<sup>1</sup>; Bogdan A. Matache<sup>2</sup>; Todd O. McKinley, MD<sup>3</sup>; Edward J. Harvey, MD, MSc, FRCSC<sup>1</sup>; <sup>1</sup>Division of Orthopaedic Surgery, Montreal General Hospital, McGill University Health Center, Montreal, Quebec, Canada; <sup>2</sup>Faculty of Medicine, McGill University, Montreal, Quebec, Canada; <sup>3</sup>Department of Orthopaedics and Rehabilitation, University of Iowa Hospitals and Clinics, Iowa City, Iowa, USA*
- Poster #134**  
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**Adequacy of Musculoskeletal Education Among Emergency Medicine Physicians**  
*Garet C. Comer, MD; Emily Liang; Julius A. Bishop, MD; Stanford University Medical Center, Palo Alto, California, USA*
- Poster #135**  
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**Improving Decision-Making in Fracture Care: Cognitive Bias and Rational Choice**  
*Jaimo Ahn, MD, PhD; Joseph Bernstein, MD; University of Pennsylvania, Philadelphia, Pennsylvania, USA*
- Poster #136**  
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**The Incidence of Death Following Outpatient Management of Fractures: Is Fatal Pulmonary Embolism a Common Clinical Problem?**  
*Dan E. Deakin, FRCS; Christopher G. Moran, MD; University Hospital Nottingham, Nottingham, United Kingdom*
- Poster #137**  
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**CT Angiography in Lower Extremity Trauma Does Not Change Management Without Corresponding Physical Examination Findings**  
*Thomas Fishler, MD; Michael P. Leslie, DO; Yale-New Haven Hospital, New Haven, Connecticut, USA*
- Poster #138**  
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**Use of the Multiple Listing Service to Obtain Surrogate Socioeconomic Data in Orthopaedic Trauma Patients**  
*Ebrahim Paryavi, MD, MPH<sup>1</sup>; Renan C. Castillo, PhD<sup>2</sup>; <sup>1</sup>R Adams Cowley Shock Trauma Center, Department of Orthopaedics, University of Maryland Medical School, Baltimore, Maryland, USA; <sup>2</sup>Center for Injury Research & Policy, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA*

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### **Early Evaluation of the Trauma Survivors Network at a Major Level I Trauma Center**

**Renan C. Castillo, PhD<sup>1</sup>**; Stephen T. Wegener, PhD<sup>2</sup>;  
Mary Zadnik Newell, ScD, Med, OTR/L<sup>1</sup>; Anthony R. Carlini, MS<sup>1</sup>;  
Anna N. Bradford, MSW<sup>1</sup>; Sara E. Heins, BA<sup>1</sup>; Elizabeth Wysocki, MS<sup>3</sup>;  
Andrew N. Pollak, MD<sup>3</sup>; Harry M. Teter, JD<sup>4</sup>; Ellen J. MacKenzie, PhD<sup>1</sup>;  
<sup>1</sup>Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA;  
<sup>2</sup>Johns Hopkins Medicine, Baltimore, Maryland, USA;  
<sup>3</sup>University of Maryland Medical School, Baltimore, Maryland, USA;  
<sup>4</sup>American Trauma Society, Upper Marlboro, Maryland, USA

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### **Teamwork in Trauma: System Adjustment to a Protocol for Management of Multiply Injured Patients**

**Heather A. Vallier, MD**; Timothy A. Moore, MD; Andrea J. Dolenc, BS;  
John J. Como, MD; Michael P. Steinmetz, MD; Karl G. Wagner, MD;  
Charles E. Smith, MD; Patricia A. Wilczewski, RN, BSN;  
MetroHealth Medical Center, Cleveland, Ohio, USA

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### **Predictive Ability of the Orthopaedic Trauma Association Open Fracture Classification**

Richard B. Barber, MD<sup>1</sup>; **Julie Agel, ATC<sup>2</sup>**; Todd Rockwood, PhD<sup>3</sup>;  
<sup>1</sup>Christus Spohn Memorial Hospital, Corpus Christi, Texas, USA;  
<sup>2</sup>Harborview Medical Center, Department of Orthopaedics,  
Seattle, Washington, USA;  
<sup>3</sup>University of Minnesota, Division of Health Policy & Management,  
Minneapolis, Minnesota, USA

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### **The Cost of Saying Yes: Hand Transfers to a Level I Trauma Center**

**Lauren N. Hinojosa, MD**; Kelly E. Cline, MD; Gregory Ford, RN;  
Adam J. Starr, MD;  
Department of Orthopaedic Surgery, University of Texas Southwestern Medical  
Center, Dallas, Texas, USA

Poster #143  
(p. )

### **Who Needs an Orthopaedic Trauma Surgeon? An Analysis of U.S. National Injury Patterns**

**R. Carter Clement, BSE**; Michael J. Kallan, MS; Brendan G. Carr, MD;  
Patrick M. Reilly, MD; Samir Mehta, MD;  
University of Pennsylvania Department of Orthopaedics,  
Philadelphia, Pennsylvania, USA

Poster #144  
(p. )

### **Short-Handed: The Lack of Hand Coverage in South Central USA**

**Lauren N. Hinojosa, MD**; Timothy Brown, MD; Sheena R. Black, MD;  
Sheri Glaser, BSN; Marissa Daniels, BA; Adam J. Starr, MD;  
Department of Orthopaedic Surgery, University of Texas Southwestern Medical  
Center, Dallas, Texas, USA

Poster #145  
(p. )

### **Occupational Injury Among Orthopaedic Surgeons: A Lack of Resources**

William T. Davis, BS; **A. Alex Jahangir, MD**; Mallory Powell, BA;  
William T. Obremesky, MD, MPH; Manish K. Sethi, MD;  
Vanderbilt University Medical Center, Nashville, Tennessee, USA

See pages 97 - 144 for financial disclosure information.

**Poster #146**  
(p. )

**Orthopaedic Surgeons' Knowledge and Attitudes in the Clinical Identification of Intimate Partner Violence Against Women: A Survey of Surgeon Members of the OTA**

*Gregory J. Della Rocca, MD, PhD, FACS<sup>1</sup>; Sheila Sprague, MSc<sup>2</sup>; Sonia Dosanjh, MSW<sup>2</sup>; Emil H. Schemitsch, MD, MSc, FRCS(C)<sup>3</sup>; Mohit Bhandari, MD, PhD, FRCSC<sup>2</sup>;*

<sup>1</sup>*Department of Orthopaedic Surgery, University of Missouri, Columbia, Missouri, USA;*

<sup>2</sup>*Division of Orthopaedic Surgery and the Departments of Surgery and of Clinical Epidemiology and Biostatistics, McMaster University, Hamilton, Ontario, Canada;*

<sup>3</sup>*Division of Orthopaedics, Department of Surgery, University of Toronto, St. Michael's Hospital, Toronto, Ontario, Canada*

**Poster #147**  
(p. )

**Risk of Hospital Readmission in Orthopaedic Trauma: Using Electronic Medical Records to Improve Quality of Care**

*Holman Chan, MD; Catherine A. Humphrey, MD; Jonathan M. Gross, MD, MPH; John P. Ketz, MD; John T. Gorczyca, MD; Strong Memorial Hospital, Rochester, New York, USA*

**Poster #148**  
(p. )

**The Influence of Body Mass Index on the Clinical Course of Multiple Trauma Patients**

*Frank Hildebrand, MD<sup>1</sup>; Hagen Andruszkow, MD<sup>1</sup>; Juliane Veh<sup>1</sup>; Christian Krettek, MD<sup>1</sup>; Michael Frink, MD<sup>2</sup>;*

<sup>1</sup>*Trauma Department, Hannover Medical School, Hannover, Germany;*

<sup>2</sup>*Trauma Department, Hand and Reconstructive Surgery Unit, University of Marburg, Marburg, Germany*

**Poster #149**  
(p. )

**Preoperative Lactate Does Not Predict Pulmonary Complications in Multiple Trauma Patients With a Femoral Shaft Fracture Treated With Early Total Care**

*Justin E. Richards, MD<sup>1</sup>; Sean M. Griffin, MD<sup>2</sup>; Daniel M. Koehler, BS<sup>1</sup>; Michael J. Bosse, MD<sup>2</sup>; William T. Obremskey, MD, MPH<sup>1</sup>; Jason M. Evans, MD<sup>1</sup>;*

<sup>1</sup>*Vanderbilt University Medical Center, Nashville, Tennessee, USA;*

<sup>2</sup>*Carolinas Medical Center, Charlotte, North Carolina, USA*

**Poster #150**  
(p. )

**Critical Care Benefits of Rib Fracture Fixation: A Meta-Analysis**

*Gerard Slobogean, MD, MPH, FRCSC; Terri Sun, BSc; Cailan MacPherson, MD, MHSc; Morad Hameed, MD, MPH, FRCSC; University of British Columbia, Vancouver, British Columbia, Canada*

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## SCIENTIFIC POSTERS

Poster #151  
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### Increased Morbidity and Mortality After Bilateral Femoral Shaft Fractures?

**Philipp Kobbe, MD, PhD<sup>1</sup>**; Fabian Micansky<sup>1</sup>; Philipp Lichte, MD<sup>1</sup>; Richard M. Sellei, MD<sup>1</sup>; Roman Pfeifer, MD<sup>1</sup>; Derek G. Dombroski, MD<sup>2</sup>; Rolf Lefering, PhD<sup>3</sup>; Hans-Christoph Pape, MD<sup>1</sup>;  
<sup>1</sup>Department of Orthopaedic Trauma Surgery, University Hospital RWTH, Aachen, Germany;  
<sup>2</sup>Parkland Health and Hospital System, Department of Orthopaedic Surgery, Dallas, Texas, USA;  
<sup>3</sup>Institute for Research in Operative Medicine, Cologne Merheim Medical Center (CMMC), University of Witten-Herdecke, Witten, Germany

Poster #152  
(p. )

### Operative Stabilization of Rib Fractures: Initial Experiences and Clinical Outcomes

**Benjamin C. Taylor, MD**; Bruce G. French, MD; Attila Poka, MD; Michael Principe, DO;  
Grant Medical Center, Columbus, Ohio, USA

Poster #153  
(p. )

### Which Injuries Below the Knee Joint Affect the Late Outcome in Patients With Multiple Injuries?

**Roman Pfeifer, MD**; Philipp Kobbe, MD, PhD; Richard M. Sellei, MD; Matthias Knoke, MD; Hans-Christoph Pape, MD;  
RWTH Aachen University, University Clinic Aachen, Department of Trauma Surgery, Aachen, Germany

Poster #154  
(p. )

### Volume of Lung Contusion as a Predictor of ARDS in the Multiple Trauma Patient

**Lars M. Qvick, MD**; Mark J. Anders, MD; Cathy Buyea, MS; Christopher E. Mutty, MD; Lawrence B. Bone, MD;  
State University of New York at Buffalo School of Medicine, Erie County Medical Center, Buffalo, New York, USA

Poster #155  
(p. )

### The Psychological Consequences and Benefits of Traumatic Injury

Jennifer Steel, PhD<sup>1</sup>; Dana J. Farrell, BS<sup>2</sup>; Peter Siska, MD<sup>2</sup>; Maranda N. Friday, MS<sup>1</sup>; Kendal A. Kingsley, MS<sup>1</sup>; Tiana L. Robinson, MS<sup>1</sup>; Hans-Christoph Pape, MD<sup>2</sup>; **Ivan S. Tarkin, MD<sup>2</sup>**;  
<sup>1</sup>Center for Excellence in Behavioral Medicine, Department of Surgery and Psychiatry, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania, USA;  
<sup>2</sup>Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

Poster #156  
(p. )

### The Impact of Major Operative Fractures in Blunt Abdominal Injury

Nickolas J. Nahm, MD; John J. Como, MD; **Timothy A. Moore, MD**; Heather A. Vallier, MD;  
MetroHealth Medical Center, Cleveland, Ohio, USA



Poster #157  
(p. )

**A Prospective Comparison of Two Approved Systems for Autologous Bone Marrow Concentration Demonstrated Nonequivalency in Progenitor Cell Number and Concentration**

**Vishal Hegde, BA<sup>1,2</sup>**; Owolabi Shonuga, BS<sup>1,2</sup>; Joseph M. Lane, MD<sup>1</sup>; Scott J. Ellis, MD<sup>1</sup>; Austin T. Fragomen, MD<sup>1</sup>; Valery Kudryashov<sup>1</sup>;  
<sup>1</sup>Hospital for Special Surgery, New York, New York, USA;  
<sup>2</sup>Weill Cornell Medical College, New York, New York, USA

Poster #158  
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**Distal Locking Using an Electromagnetic Field-Guided Computer-Based Real Time System for Orthopaedic Trauma Patients**

**Maxwell K. Langfitt, MD**; Jason J. Halvorson, MD; Aaron T. Scott, MD; Beth P. Smith, PhD; Gregory B. Russell, MS; Riyaz H. Jimmah, MD; Anna N. Miller, MD; Eben A. Carroll, MD;  
Wake Forest Baptist Medical Center, Winston-Salem, North Carolina, USA

Poster #159  
(p. )

**Platelet-Rich Plasma in Delayed Unions**

Daniel G. Monzon, MD<sup>1</sup>; Alberto Cid Casteulani, MD<sup>2</sup>; Kenneth Iserson, MD<sup>3</sup>;  
**Eliseo Firman, MD<sup>2</sup>**; Santiago Svarzchtein, MD<sup>2</sup>; Sebastian Sasaki, MD<sup>2</sup>;  
Diego Roncolato, MD<sup>2</sup>;  
<sup>1</sup>Hospital Italiano de Buenos Aires, Buenos Aires, Argentina;  
<sup>2</sup>Centro Medico Integral Fitz Roy, Buenos Aires, Argentina;  
<sup>3</sup>University of Arizona, Tucson, Arizona, USA

Poster #160  
(p. )

**The Utility of the Free Anterolateral Thigh Flap for Reconstruction of Soft-Tissue Defects Associated With Extremity Fractures**

Ariel Bowman, MS<sup>1</sup>; Jaimo Ahn, MD, PhD<sup>2</sup>; L. Scott Levin, MD<sup>2</sup>;  
**Samir Mehta, MD<sup>2</sup>**; Stephen J. Kovach, MD<sup>3</sup>;  
<sup>1</sup>Perleman School of Medicine at the University of Pennsylvania, Philadelphia, Pennsylvania, USA;  
<sup>2</sup>Department of Orthopaedic Surgery, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania, USA;  
<sup>3</sup>Division of Plastic Surgery, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania, USA

Poster #161  
(p. )

**•rhBMP-2 in the Treatment of Long Bone Nonunions Is No Advantage Over Autogenous Bone Graft Alone**

Jordanna Forman, BS; Richelle C. Takemoto, MD; **Kenneth A. EgoI, MD**;  
NYU Hospital for Joint Diseases, New York, New York, USA

Poster #162  
(p. )

**Does Adding a Nail Make a Difference?**

**Daniel S. Chan, MD<sup>1</sup>**; Gerald E. Alexander, III, MD<sup>2</sup>; Ian R. Smithson, MD<sup>2</sup>;  
Roy Sanders, MD<sup>1</sup>; H. Claude Sagi, MD<sup>1</sup>;  
<sup>1</sup>Orthopaedic Trauma Service, Florida Orthopaedic Institute, Tampa, Florida, USA;  
<sup>2</sup>University of South Florida, Tampa, Florida, USA

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## SCIENTIFIC POSTERS

- Poster #163**  
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**Locked 90° Blade Plates in Metaphyseal Proximal Humerus Nonunion**  
*Christian Allende, MD; Martin Mangupli, MD;*  
*Hospital Nacional de Clínicas, Cordoba, Argentina*
- Poster #164**  
(p. )  
**If Treatment of Nonunions With ICBG Works, Adding BMP-2 Must Work Better—Right or Wrong?**  
*William M. Ricci, MD; Philipp N. Streubel, MD;*  
*Christopher M. McAndrew, MD; Michael J. Gardner, MD;*  
*Washington University School of Medicine, Saint Louis, Missouri, USA*
- Poster #165**  
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**Treatment of Open Supracondylar Femur Fractures With Segmental Bone Loss**  
*William M. Ricci, MD; Philip N. Streubel, MD;*  
*Christopher M. McAndrew, MD; Michael J. Gardner, MD;*  
*Washington University School of Medicine, Saint Louis, Missouri, USA*
- Poster #166**  
(p. )  
**A New Classification for Complex Lumbosacral Injuries**  
*Ronald A. Lehman, Jr., MD<sup>1</sup>; Daniel G. Kang, MD<sup>1</sup>; Carlo Bellabarba, MD<sup>2</sup>;*  
*<sup>1</sup>Walter Reed National Military Medical Center, Bethesda, Maryland, USA;*  
*<sup>2</sup>University of Washington Medical Center, Seattle, Washington, USA*
- Poster #167**  
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**Posterior Stabilization of Thoracolumbar Spine Fractures: Retrospective Analysis of Percutaneous Versus Open Management**  
*Miguel Pishnamaz, MD; Stavros Oikonomidis, MD; Richard M. Sellei, MD;*  
*Philipp Lichte, MD; Klemens Horst, MD; Hans-Christoph Pape, MD;*  
*Philipp Kobbe, MD, PhD;*  
*Department of Orthopaedic and Trauma Surgery,*  
*University Hospital RWTH, Aachen, Germany*
- Poster #168**  
(p. )  
**The Reliability of the Thoracolumbar Injury Classification and Severity Score Among Orthopaedic Surgeons at Different Levels of Training**  
*Adam J. Bevevino, MD; Ronald A. Lehman, MD; Daniel G. Kang, MD;*  
*John P. Cody, MD; Robert W. Tracey, MD; Donald Hope, MD;*  
*Walter Reed National Military Medical Center, Bethesda, Maryland, USA*
- Poster #169**  
(p. )  
**Reliability of the Subaxial Cervical Spine Injury Classification System for Orthopaedic Surgeons at Different Training Levels**  
*Daniel G. Kang<sup>1</sup>; Ronald A. Lehman Jr<sup>1</sup>; Adam J. Bevevino<sup>1</sup>; John P. Cody<sup>1</sup>;*  
*Alpesh A. Patel<sup>2</sup>; Scott C. Wagner<sup>1</sup>; Donald N. Hope<sup>1</sup>;*  
*<sup>1</sup>Walter Reed National Military Medical Center, Bethesda, Maryland, USA;*  
*<sup>2</sup>Loyola University Health System, Chicago, Illinois, USA*

## PEDIATRIC

## Poster #170

(p. )

**The Perfused, Pulseless Supracondylar Humerus Fracture: Intermediate Follow-up of Vascular Status and Function**

Steven L. Frick, MD; Christopher Bray, MD; Brian Scannell, MD;  
**J. Benjamin Jackson, III, MD**; Timothy S. Roush, MD, MPH;  
 Brian K. Brighton, MD, MPH;  
 Carolinas Medical Center, Charlotte, North Carolina, USA

## Poster #171

(p. )

**A Radiographic Study of the Ossification of the Posterior Wall of the Acetabulum: Implications for the Evaluation of Posterior Wall Fractures in Children**

Peter D. Fabricant, MD; Brandon P. Hirsch, MD; Ian Holmes, BS;  
 Milton T. M. Little, MD; Marschall B. Berkes, MD; Eric A. Bogner, MD;  
 David L. Helfet, MD; Dean G. Lorich, MD; Daniel W. Green, MD;  
 Hospital for Special Surgery, New York, New York, USA

## Poster #172

(p. )

**Pediatric Supracondylar Humerus Fractures: A Technique to Aid in Closed Reduction**

Mary A. Herzog, MD<sup>1</sup>; Shelley M. Oliver, MD<sup>1</sup>; James R. Ringler, MD<sup>1,2</sup>;  
 Debra L. Sietsema, PhD<sup>2</sup>; Clifford B. Jones, MD<sup>1,2</sup>;  
<sup>1</sup>Grand Rapids Medical Education Partners Orthopaedic Surgery  
 Residency Program, Grand Rapids, Michigan, USA;  
<sup>2</sup>Orthopaedic Associates of Michigan, Michigan State University,  
 Grand Rapids, Michigan, USA

## Poster #173

(p. )

**Association of Pelvic Ring Injuries in Pediatric and Adolescent Patients With Injury Severity Score and Need for Transfusion**

Laura W. Lewallen, MD; S. Andrew Sems, MD; Amy L. McIntosh, MD;  
 Mayo Clinic, Rochester, Minnesota, USA

## Poster #174

(p. )

**Management and Outcomes of Adolescent Supracondylar Humerus Fractures**

Bryan J. Loeffler, MD<sup>1</sup>; Steven L. Frick, MD<sup>2</sup>; Brian K. Brighton, MD<sup>2</sup>;  
 R. Glenn Gaston, MD<sup>3</sup>; Virginia F. Casey, MD<sup>3</sup>; Melissa Earles, MD<sup>4</sup>;  
 Kyle J. Jeray, MD<sup>4</sup>; David Bissing<sup>5</sup>; Lisa K. Cannada, MD<sup>5</sup>;  
 Robert A. Hymes, MD<sup>6</sup>;  
<sup>1</sup>Thomas Jefferson University, Philadelphia, Pennsylvania, USA;  
<sup>2</sup>Carolinas Medical Center, Charlotte, North Carolina, USA;  
<sup>3</sup>OrthoCarolina, Charlotte, North Carolina, USA;  
<sup>4</sup>Greenville Hospital System, Greenville, South Carolina, USA;  
<sup>5</sup>Saint Louis University, Saint Louis, Missouri, USA;  
<sup>6</sup>Inova Fairfax Hospital, Falls Church, Virginia, USA

## Poster #175

(p. )

**Surgical Hip Dislocation Is Safe for the Treatment of Incomplete Reduction Following Traumatic Hip Instability in Adolescents**

David A. Podeszwa, MD; Adriana DelaRocha, MS; Daniel J. Sucato, MD;  
 Department of Orthopaedic Surgery, University of Texas Southwestern  
 and Texas Scottish Rite Hospital for Children, Dallas, Texas, USA

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## SCIENTIFIC POSTERS

- Poster #176**  
(p. )  
**Incidence, Bacteriology, and Risk Factors of Infection in Smooth Wire Fixation in Pediatric Orthopaedic Surgery**  
*Abtin Foroohar, MD; Richard Tosti, MD; Jennifer Brey, MD; Martin Herman, MD; Peter Pizzutillo, MD; St. Christopher's Hospital for Children, Philadelphia, Pennsylvania, USA*
- Poster #177**  
(p. )  
**Triplane/Tillaux Fractures: How Much Gap or Step is Acceptable?**  
*Imran K. Choudhry, MD<sup>1</sup>; Alvin H. Crawford, MD<sup>2</sup>; Charles T. Mehlman, DO, MPH; Eric J. Wall, MD<sup>2</sup>; Emily A. Eisman, MS<sup>2</sup>; Lindsay M. Wilson, BA<sup>2</sup>;  
<sup>1</sup>University of Cincinnati Department of Orthopaedics, Cincinnati, Ohio, USA;  
<sup>2</sup>Cincinnati Children's Hospital, Cincinnati, Ohio, USA*
- TIBIA**  
**Poster #178**  
(p. )  
**Tibial Nail Distal Positioning: A Radiographic Study**  
*Travis E. Marion, MD; Steven R. Papp, MD; Wade T. Gofton, MD, MEd; Allan Liew, MD; University of Ottawa, Ottawa, Ontario, Canada*
- Poster #179**  
(p. )  
**Tibia-Based Referencing for Standard Proximal Tibial Radiographs During Intramedullary Nailing**  
*Jesse E. Bible, MD; Ankeet A. Choxi, BE; Sravan Dhulipala, BS; Jason M. Evans, MD; Hassan R. Mir, MD; Vanderbilt Orthopaedic Institute, Nashville, Tennessee, USA*
- Poster #180**  
(p. )  
**Identification of Optimal Control Compartments for Near-Infrared Spectroscopy Assessment of Lower Extremity Compartmental Perfusion**  
*Keith Jackson, MD<sup>2</sup>; Ashley L. Cole, MPH<sup>1</sup>; Benjamin K. Potter, MD<sup>3</sup>; Tracy L. Kinsey, MSPH; Michael S. Shuler, MD; Emily K. Smith, MPH; Brett A. Freedman, MD  
<sup>1</sup>University of Georgia, Athens, Georgia, USA;  
<sup>2</sup>Cincinnati Children's Hospital, Cincinnati, Ohio, USA  
<sup>3</sup>Department of Orthopaedics and Rehabilitation, Walter Reed National Military Medical Center, Bethesda, Maryland, USA*
- Poster #181**  
(p. )  
**Effect of Tibial Nonunion on Health-Related Quality of Life**  
*Mark R. Brinker, MD<sup>1</sup>; Bryan D. Hanus<sup>1</sup>; Milan K. Sen, MD<sup>2</sup>; Daniel P. O'Connor, PhD<sup>2</sup>;  
<sup>1</sup>Department of Orthopaedic Surgery, University of Texas Medical School at Houston, Houston, Texas, USA;  
<sup>2</sup>Department of Health and Human Performance, University of Houston, Houston, Texas, USA*
- Poster #182**  
(p. )  
**Faster Surgery, Faster Union, But Less Stable Fixation in 50 Tibial Fractures Treated With the Fixion Expandable Intramedullary Nail Compared With a Matched Series of Interlocked Nails**  
*Toby W. Briant-Evans, FRCS; Jonathan L. Hobby, FRCS; Geoff J. Stranks, FRCSEd; Nigel D. Rossiter, FRCSEd; Basingstoke and North Hampshire Hospital, Basingstoke, Hampshire, United Kingdom*

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- Poster #183**  
(p. )
- Clamp-Assisted Intramedullary Nailing of Closed Spiral (OTA 42-A1 and B1) Tibia Fractures: A Comparative Study**  
*Cory A. Collinge, MD<sup>1</sup>; Michael J. Beltran, MD<sup>2</sup>; Henry A. Dollahite, BS<sup>1</sup>; Florian G. Huber, MD<sup>3</sup>;*  
<sup>1</sup>Harris Methodist Hospital, Fort Worth, Texas, USA;  
<sup>2</sup>San Antonio Military Residency, San Antonio, Texas, USA;  
<sup>3</sup>Peninsula Orthopedic Associates, Salisbury, Maryland, USA
- Poster #184**  
(p. )
- Increased Nonunion Rate and Delayed Union of Distal Tibia Fractures Treated With Intramedullary Nails and Angle Stable Interlocking Screws**  
*Kevin M. Kuhn, MD<sup>1</sup>; Jason W. Stoneback, MD<sup>2</sup>;*  
*John A. Boudreau, MD<sup>2</sup>; J. Tracy Watson, MD<sup>2</sup>;*  
<sup>1</sup>Naval Medical Center San Diego, San Diego, California, USA;  
<sup>2</sup>Saint Louis University Hospital, Saint Louis, Missouri, USA
- Poster #185**  
(p. )
- Tibial Nailing in the Setting of a Traumatic Knee Arthrotomy**  
*Jennifer M. Bauer, MD; Jesse E. Bible, MD; Hassan R. Mir, MD;*  
*Vanderbilt Orthopaedic Institute, Nashville, Tennessee, USA*
- Poster #186**  
(p. )
- Orthopaedic Infection Reduces Chances of Returning to Duty**  
*Matthew A. Napierala, MD; Jessica C. Rivera, MD; Clinton K. Murray, MD;*  
*Travis C. Burns, MD; Joseph C. Wenke, PhD; Joseph R. Hsu, MD;*  
*Skeletal Trauma Research Consortium (STReC);*  
*San Antonio Military Medical Center, Fort Sam Houston, Texas, USA*
- Poster #187**  
(p. )
- Quantification of Anterior Cortical Bone Removal and Intermeniscal Ligament Damage at the Tibial Nail Entry Zone**  
*Jesse E. Bible, MD; Ankeet A. Choxi, BE; Sravan Dhulipala, BS;*  
*Jason M. Evans, MD; Hassan R. Mir, MD;*  
*Vanderbilt Orthopaedic Institute, Nashville, Tennessee, USA*
- Poster #188**  
(p. )
- Posterolateral Depression in Tibial Plateau Fractures: A Novel Technique for Reduction and Fixation**  
*Adam A. Sassoon, MD; Joseph R. Cass, MD; William W. Cross, MD;*  
*Michael E. Torchia, MD; Stephen A. Sems, MD;*  
*Mayo Clinic, Rochester, Minnesota, USA*
- Poster #189**  
(p. )
- Do Open Fractures Influence Postoperative Length of Stay? A Retrospective Review of Isolated Femur and Tibia Fractures at a Level I Center**  
*Jake McClure, BS; Tyler Armstrong BS; A. Alex Jahangir, MD;*  
*Jesse Ehrenfeld, MD, MPH; William T. Obremskey, MD, MPH;*  
*Khensani N. Marolen, MPH; Manish K. Sethi, MD;*  
*Vanderbilt University Medical Center, Nashville, Tennessee, USA*

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SCIENTIFIC POSTERS

Poster #190  
(p. )

**Prospective Randomized Evaluation of Outcomes With Different Tibial Nail Entry Portals**

Michael P. McClincy, MD; Dana J. Farrell, BS; Peter A. Siska, MD; Gary S. Gruen, MD; James J. Irrgang, PT, PhD, ATC, FAPTA; Ivan S. Tarkin, MD; Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

POSTERS

BASIC SCIENCE

Poster #191  
(p. )

**•Recombinant Human Platelet-Derived Growth Factor-BB (rhPDGF-BB) and Beta-Tricalcium Phosphate (β-TCP) in Foot and Ankle Fusions**

Michael. S. Pinzur, MD<sup>1</sup>; Christopher W. DiGiovanni, MD<sup>2</sup>; Sheldon S. Lin, MD<sup>3</sup>; <sup>1</sup>Loyola University Medical Center, Maywood, Illinois, USA; <sup>2</sup>Brown University, Providence, Rhode Island, USA; <sup>3</sup>New Jersey Medical School, Newark, New Jersey, USA

Poster #192  
(p. )

**Effect of Bone Morphogenetic Protein, Granulocyte–Colony Stimulating Factor, and Bone Marrow Stem Cells on Fracture Healing in Rats with Osteoporosis: A Comparative Study**

Vijay G. Goni, MD; Kishan R. Bhagwat, MD; Bikash Medhi, MD; M. Thungapathra, MD; Ashim Das, MD; Post Graduate Institute of Medical Education & Research (PGIMER), Chandigarh, India

(p. )



**BEST TRAUMA RELATED POSTER 2012 ORS MEETING Conversion from External Fixator to Intramedullary Nail Impairs Fracture Healing Particularly After a Severe Trauma**

S. Recknagel<sup>1</sup>; R. Bindl<sup>1</sup>; T. Wehner<sup>1</sup>; C. Ehrnthaller<sup>1</sup>; F. Gebhard<sup>2</sup>; M. Huber-Lang<sup>2</sup>; L. Claes<sup>1</sup>; A. Ignatius<sup>1</sup>; <sup>1</sup>Institute of Orthopaedic Research and Biomechanics, Center of Musculoskeletal Research, University of Ulm, Ulm, Germany <sup>2</sup>Department of Traumatology, Hand-, Plastic-, and Reconstructive Surgery, Center of Musculoskeletal Research, University of Ulm, Ulm, Germany

**EVIDENCE-BASED MEDICINE (EBM) COMMITTEE POSTER OTA Current Practice Survey of Antibiotic s & Early Treatment in Open Fractures**

William T. Obremskey, MD, MPH; Cory A. Collinge, MD; Steven A. Olson, MD; H. Claude Sagi, MD; Paul Tornetta, III, MD

**EVIDENCE-BASED MEDICINE (EBM) COMMITTEE POSTER OTA Current Practice Survey of Definitive Treatment of Open Fractures**

William T. Obremskey, MD, MPH; Cory A. Collinge, MD; Steven A. Olson, MD; H. Claude Sagi, MD; Paul Tornetta, III, MD

See pages 97 - 144 for financial disclosure information.



## INTERNATIONAL POSTER LISTING

- Int'l Poster #1**  
(p. ) **Functional Outcome of Patients With Long-Bone Fracture Treated With External Fixation and Open Interlocked Intramedullary Nailing With Bone Grafting**  
*Raymar L. Sibonga, MD; Co-Authors \_\_\_\_\_?*  
*Institution(s) \_\_\_\_\_?*
- Int'l Poster #2**  
(p. ) **Internal Fixation Augmented With Antibiotic-Loaded Bone Cement Beads and Rods in Delayed/Neglected Open Complex Fractures of the Distal Femur**  
*Harpal Singh Selhi, MD; Co-Authors \_\_\_\_\_?*  
*Institution(s) \_\_\_\_\_?*
- Int'l Poster #3**  
(p. ) **Less Invasive Stabilization System: Is This the Ultimate Solution for Distal Femur Fractures?**  
*Bruno Bella guarda Baptista; Ricardo Antonio Tavares; João Batista Manzolli Torres; Mauricio Kfuri, MD; DEGREES???*  
*Ribeirao Preto Medical School, São Paulo University, São Paulo, Brazil*
- Int'l Poster #4**  
(p. ) **Floating Knee and Retrograde Femoral Nail: Is This Combination Reliable?**  
*Bruno Bella guarda Baptista; Leonardo Mascarenhas; Marcelo Castiglia; Mauricio Kfuri, MD; DEGREES???*  
*Ribeirao Preto Medical School, São Paulo University, São Paulo, Brazil*
- Int'l Poster #5**  
(p. ) **Intramedullary Nailing for Pertrochanteric Fractures: Do We Really Need Traction Tables?**  
*Rogério Carneiro Bitar; Mauricio Kfuri, MD; DEGREES???*  
*Ribeirao Preto Medical School, São Paulo University, São Paulo, Brazil*
- Int'l Poster #6**  
(p. ) **Management of Open Tibia Fractures in the Developing World Using the SIGN Intramedullary Nail**  
*Daniel Galat, MD;*  
*Tenwek Hospital, Bomet, Kenya*
- Int'l Poster #7**  
(p. ) **One Prone Position, Double Incision, and Triple Fixation for the Treatment of Trimalleolar Fractures**  
*Baoqing Yu, MD;*  
*Department of Orthopaedics, Changhai Hospital, The Second Military Medical University, Shanghai, China*
- Int'l Poster #8**  
(p. ) **Ankle Fracture Fixation With a Novel Intramedullary Photodynamic Polymeric Bone Pin: A Case Series Review**  
*Thomas Gausepohl, MD;*  
*Klinikum Vest, North Rhine-Westphalia, Germany*

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- Int'l Poster #9**  
(p. ) **Fracture Management in Mirwais Hospital, Kandahar, Afghanistan in 2010**  
*Abdul Ghani Mesbah, MD, MS; Co-Authors \_\_\_\_\_?*  
*Institution \_\_\_\_\_? Kandahar, Afghanistan*
- Int'l Poster #10**  
(p. ) **Three Dimensional Fluoroscopy for Detection of Intra-Articular Hardware in a Proximal Humerus Fracture Model: A Laboratory Study**  
*Yoram A. Weil, MD; Shaul Beyth, MD; Amal Houry, MD;*  
*Meir Liebergall, MD; Ori Safran, MD;*  
*Department of Orthopaedics, Hadassah Hebrew University Hospital, Jerusalem, Israel*
- Int'l Poster #11**  
**WITHDRAWN**
- Int'l Poster #12**  
(p. ) **Fluid Resuscitation Using Enteral Route Is a Safe and Effective Alternative to Parental Resuscitation in Patients Undergoing Major Elective Surgery**  
*Professor Rajeshwar Srivastava, Sr.; Kavita Baghel; Saloni Raj;*  
*DEGREES???*  
*KG Medical College, Lucknow, India*
- Int'l Poster #13**  
(p. ) **Locked Minimally Invasive Plating (PCCP) Versus Fourth-Generation Nailing (Trigen Intertan Nail) in Unstable Pertrochanteric Femur Fractures: A Biomechanical Evaluation**  
*Matthias Knoke, MD<sup>1</sup>; Gertraud Gradl, MD<sup>2</sup>; Andreas Prescher, MD<sup>3</sup>;*  
*Richard Martin Sellei, MD<sup>1</sup>; Philipp Kobbe, MD<sup>1</sup>; Roman Pfeifer, MD<sup>1</sup>;*  
*Philipp Lichte, MD<sup>1</sup>; Hans-Christoph Pape, MD<sup>1</sup>;*  
*<sup>1</sup>Department of Orthopedic and Trauma Surgery, Medical Faculty, RWTH Aachen University, Aachen, Germany;*  
*<sup>2</sup>Department of Orthopaedic Surgery, Massachusetts General Hospital, Boston, Massachusetts, USA;*  
*<sup>3</sup>Department of Molecular and Cellular Anatomy, Medical Faculty, RWTH Aachen University, Aachen, Germany*
- Int'l Poster #14**  
(p. ) **Comparison of Different Techniques for Flexible Fixation of Open Book Type Pelvic Injuries With Two-Leg Alternate Loading: A Biomechanical Study**  
*Fabian Stuby, MD<sup>1</sup>; Yash Agarwal, PhD<sup>2</sup>; Markus Windolf, MSc<sup>2</sup>;*  
*Thomas Shiozawa, MD<sup>3</sup>; Björn Gunnar Ochs, MD<sup>1</sup>; Christoph Gonser, MD<sup>1</sup>;*  
*Ulrich Stöckle, PhD<sup>1</sup>; Boyko Gueorguiev, PhD<sup>2</sup>;*  
*<sup>1</sup>BGU, Eberhard Karls University, Tuebingen, Germany;*  
*<sup>2</sup>AO Research Institute Davos, Davos, Switzerland;*  
*<sup>3</sup>Anatomical Institute, Eberhard Karls University, Tuebingen, Germany*



- Int'l Poster #15**  
(p. )
- Evaluation of a New Fixation Concept for Intramedullary Nailing of Proximal Humeral Fractures: A Biomechanical Study**  
*Boylko Gueorguiev, PhD<sup>1</sup>; Stephan Rothstock, PhD<sup>1</sup>; Markus Windolf, MSc<sup>1</sup>; Martin Kloub, MD<sup>2</sup>; Damiano Schiuma, MSc<sup>1</sup>; Michael Plecko<sup>3</sup>, MD;*  
<sup>1</sup>AO Research Institute Davos, Davos, Switzerland;  
<sup>2</sup>Hospital Ceske Budejovice, Ceske Budejovice, Czech Republic;  
<sup>3</sup>University Hospital Zurich, Zurich, Switzerland
- Int'l Poster #16**  
(p. )
- Biomechanical Evaluation of Locking Plate Fixation of Proximal Humeral Fractures Augmented with Calcium Phosphate Cement**  
*Gertraud Gradl, MD<sup>1</sup>; Matthias Knobe, MD<sup>1</sup>; Marcus Stoffel<sup>2</sup>; Andreas Prescher, MD<sup>3</sup>; Timm Dirrichs<sup>4</sup>; Hans-Christoph Pape, MD<sup>1</sup>;*  
<sup>1</sup>Department for Trauma Surgery, University of Aachen, Aachen, Germany;  
<sup>2</sup>Institute of General Mechanics, University of Aachen, Aachen, Germany;  
<sup>3</sup>Institute of Molecular and Cellular Anatomy, University of Aachen, Aachen, Germany;  
<sup>4</sup>Department for Diagnostic and Interventional Radiology, University of Aachen, Aachen, Germany
- Int'l Poster #17**  
(p. )
- Reaching Agreement Between Trainees and Consultants in Their Assignment of the Young and Burgess Radiographic Classifications of Pelvic Fractures in the Emergency Room**  
*Thomas Kurien, MBBS, MSc, BS; D. P. Forward; D. M. Hahn; A. Fowler; M. Raglan; R. G. Pearson; C. G. Moran;*  
Division of Trauma and Accident Surgery, Nottingham University Hospital, Nottingham, England, United Kingdom
- Int'l Poster #18**  
(p. )
- Pelvic Fracture Classification as a Key to Transfusion Requirements**  
*Nikolaos K. Kanakaris, MD; O. Obakponovwe; K. Harvey Kelly; R. M. West; Peter V. Giannoudis, MD;*  
Academic Department of Trauma and Orthopaedics, Leeds Teaching Hospitals, School of Medicine, University of Leeds, Leeds, United Kingdom
- Int'l Poster #19**  
(p. )
- Long-Term Follow-up of Opioid Use in Patients With Acetabular Fractures**  
*Karl-Åke Jansson, PhD;*  
Karolinska Institutet, Stockholm, Sweden
- Int'l Poster #20**  
(p. )
- Comparison of Acetabular Fracture Reduction Quality by the Iliioinguinal or the Modified Stoppa Approaches**  
*Nachshon Shazar, MD; Iris Eshed, MD; Nissim Ackshota, MD; Oded Hershkowitz, MD; Alexander Hazanov, MD; Amir Herman, MD, PhD;*  
*Institution(s)\_\_\_\_\_?*
- Int'l Poster #21**  
(p. )
- Long-Term Outcome and Quality of Life of Patients With Unstable Pelvic Fracture Treated by Internal-External Fixator**  
*Gary Chen, MD<sup>1</sup>; Guo Fu, MD, PhD<sup>2</sup>;*  
<sup>1</sup>California Hospital Medical Center, Los Angeles, California, USA;  
<sup>2</sup>The First Affiliated Hospital of Sun Yat-Sen University, Guangzhou, Guangdong Province, China

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- Int'l Poster #22**  
(p. )  
**Early Experiences With a Pelvic Reduction Frame to Provide Intraoperative Femoral Head Positioning During Fixation of Difficult Acetabular Fractures**  
*Edward Britton, MB, BS; J. Stammers; P. Culpán; P. Bates; Barts and the London Hospitals Pelvic Unit, United Kingdom*
- Int'l Poster #23**  
(p. )  
**Correction and Lengthening of Posttraumatic Lower Extremity Deformities Using Intramedullary Lengthening Devices**  
*Metin Kucukkaya, MD; Ozgur Karakoyun, MD; Sami Sokucu, MD; Ramazan Soydan, MD; Istanbul Bilim University Medical Faculty, Department of Orthopaedics & Traumatology, Istanbul, Turkey*
- Int'l Poster #24**  
(p. )  
**Functional Outcome Following Floating Knee Injuries Treated by Different Surgical Methods**  
*Rajeev Kumar, MS, MBBS; Sant Ishar Singh Hospital, Pehowa*
- Int'l Poster #25**  
(p. )  
**Open Reduction of Chronic Shoulder Dislocations by an Extensile Approach, Circumferential Capsulotomy, and Mobilization of Rotator Cuff Muscles**  
*Duane Anderson, MD<sup>1</sup>; Lucas Anderson, MD<sup>2</sup>; Stephen Aoki, MD<sup>2</sup>; Segni Bekele, MD<sup>1</sup>; Abebe Chala, PT<sup>1</sup>; <sup>1</sup>Soddo Christian Hospital (SCH), Soddo Wolaitta, Ethiopia; <sup>2</sup>University of Utah Department of Orthopedics, Salt Lake City, Utah, USA*
- Int'l Poster #26**  
(p. )  
**Social Deprivation Influences the Epidemiology and Outcome of Proximal Humeral Fractures in Adults**  
*Nicholas David Clement, MBBS; Margaret M. McQueen, MD; Charles M. Court-Brown, MD; Orthopaedic Trauma Unit, Royal Infirmary Edinburgh, Edinburgh, Scotland, United Kingdom (Double Check Institution - I guessed!)*
- Int'l Poster #27**  
(p. )  
**Treatment of Bone Defects in Children Caused by Chronic Hematogenous Osteomyelitis: A Retrospective Review of 57 Patients**  
*Andrew J. Stevenson, MD; M. Stolbrink; D. Moffatt; W. J. Harrison; J. Cashman; FULL NAMES and DEGREES???*  
*Beit CURE International Hospital, Blantyre, Malawi*
- Int'l Poster #28**  
(p. )  
**Intra-Articular Fractures of the Calcaneus in Childhood**  
*Marcel Dudda, MD; C. Kruppa; J. Gefßmann; D. Seybold; T. A. Schildhauer; FULL NAMES and DEGREES???*  
*University Hospital Bergmannsheil, Ruhr University of Bochum, Bochum, Germany*

Int'l Poster #29  
(p. )

**The Gamma3 International Multicenter Prospective Clinical Follow-up Evaluation**

E. Wilde<sup>1</sup>; Arndt P. Schulz, MD, PhD<sup>1,2</sup>; N. Reimers<sup>3</sup>;  
C. Beime<sup>3</sup>; Ch. Jürgens<sup>1,2</sup> *FULL NAMES and DEGREES???*  
<sup>1</sup>University Hospital Lübeck, Lübeck, Germany;  
<sup>2</sup>BG Trauma Hospital Hamburg, Hamburg, Germany;  
<sup>3</sup>Stryker Trauma, Schönkirchen, Germany

Int'l Poster #30  
(p. )

**Multiple Fractures in the Elderly**

Nicholas D. Clement, MBBS; Stuart A. Aitken,  
Andrew D. Duckworth, MBChB, BSc (Hons); Margaret M. McQueen, MD;  
Charles M. Court-Brown, MD;  
Orthopaedic Trauma Unit, Royal Infirmary Edinburgh,  
Edinburgh, Scotland, United Kingdom (*Please double check institution—I guessed!*)

Int'l Poster #31  
(p. )

**Iizarov Use in Cambodia: Indications and Complications Compared With the Western World**

Rupert Wharton, Bm, BSc; Suzanne Zeidler; Jim Gollogly; Keith Willett, MD;  
James Aird;  
Children's Surgical Centre, Kien Khleang National Rehabilitation Center,  
Phnom Penh, Cambodia

Int'l Poster #32  
(p. )

**Revision With Plates in Humerus Nonunions Secondary to Failed Intramedullary Nails**

Christian Allende, MD; Martin M. Mangupli, MD;  
*Institution(s) \_\_\_\_\_?*

Int'l Poster #33  
(p. )

**Multiple Trauma in Children: Prognostic Value of IL-6 for Development of Posttraumatic Complications**

Frank Hildebrand, MD<sup>1</sup>; H. Andruszkow<sup>1</sup>; J. Fischer<sup>1</sup>;  
C. Krettek<sup>1</sup>; M. Frink<sup>2</sup>; *FULL NAMES and DEGREES???*  
<sup>1</sup>Trauma Department, Hannover Medical School, Hannover, Germany;  
<sup>2</sup>Trauma Department, Hand and Reconstructive Surgery Unit,  
University of Marburg, Marburg, Germany

Int'l Poster #34  
(p. )

**Is Multidetector Helical CT (MDCT) More Reliable in Diagnosing Bone Consolidation as Compared to Conventional Radiographs?**

V.A.B. Scholtes<sup>1</sup>; M. Maas<sup>2</sup>; P. Karanicolas<sup>2</sup>;  
Mohit Bhandari, MD, PhD, FRCSC<sup>3</sup>; *FULL NAMES and DEGREES???*  
Rudolf W. Poolman, MD, PhD<sup>1</sup>; P. Kloen<sup>2</sup>; on behalf of the COAST  
(Collaboration for Outcomes Assessment in Surgical Trials) Research Group;  
<sup>1</sup>OLVG (Onze Lieve Vrouwe Gasthuis), Amsterdam, the Netherlands;  
<sup>2</sup>Academic Medical Centre, Amsterdam, the Netherlands;  
<sup>3</sup>McMaster University, Hamilton, Ontario, Canada

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Int'l Poster #35  
(p. )

**The Role of the Pediatric Orthopaedic Surgeon in the Early Response to a Major Natural Disaster: A Prospective Case Study**

*Axel Gamulin, MD<sup>1</sup>; J. Armenter Duran<sup>1</sup>; M. Assal<sup>1</sup>; O. Hagon<sup>2</sup>; R. Dayer<sup>3</sup>;  
FULL NAMES and DEGREES???*

*<sup>1</sup>Division of Orthopaedics and Trauma Surgery, University Hospitals of Geneva, Geneva, Switzerland;*

*<sup>2</sup>Humanitarian Aid, Swiss Agency for Development and Cooperation, Bern, Switzerland;*

*<sup>3</sup>Division of Orthopaedic Pediatrics, University Hospitals of Geneva, Geneva, Switzerland*

## DISCLOSURE LISTING – ALPHABETICAL

Abdelgawad, Amr A. . . . . (n) . . . . .	Case Presentation Faculty
Abraham, Christine . . . . . (n) . . . . .	Poster #122
Achor, Timothy S. . . . . (n) . . . . .	Poster #1
Ackshota, Nissim . . . . . (n) . . . . .	Int'l Poster #20
Adelved, Aron . . . . . (n) . . . . .	Paper #62
Agarwal, Animesh . . . . . (3B-Medtronic; Smith & Nephew; Synthes; Acrymed, 8-Journal of Orthopaedic Trauma, 9-AAOS; Orthopaedic Research Society; Orthopaedic Trauma Association; Mid-America Orthopaedic Association; Clinical Orthopaedic Society)	Case Presentation Faculty
Agarwal, Yash . . . . . (n) . . . . .	Int'l Poster #14
Agel, Julie . . . . . (9-Orthopaedic Trauma Association. AO Foundation) . . . . .	Paper #114; Poster #141
Ahn, Jaimo . . . . . (3B-Merck (consultant for legal purposes), 8-Orthopaedia.com, Trauma Section Editor, 9-AAOS, Basic Science Evaluation Subcommittee; Foundation for Orthopedic Trauma, Research Committee; American Physician Scientists Association, Board of Directors; NBME committee for USMLE surgery test material development)	Paper #14; Posters #25, 117, 135, 160
Aird, James . . . . . (n) . . . . .	Int'l Poster #31
Aitken, Stuart A. . . . . (n) . . . . .	Paper #74; Poster #107; Int'l Poster #30
Ajayi, Adedapo . . . . . (n) . . . . .	Poster #129
Akers, Walter . . . . . (n) . . . . .	Paper #13
Alexander, Gerald, III. . . . . (n) . . . . .	Poster #162
Allende, Christian . . . . . (n) . . . . .	Poster #163; Int'l Poster #32
Allmon, Chris . . . . . (n) . . . . .	Paper #75
Almanda, Vignesh K. . . . . (n) . . . . .	Poster #124
Alsousou, Joseph . . . . . (n) . . . . .	Paper #111
Alt, Volker . . . . . (n) . . . . .	Mini Symposium Faculty
Althausen, Peter . . . . . (4-The Orthopedic Implant Company, 6-Smith & Nephew; Synthes; Stryker, 8-Journal of Orthopaedic Trauma, 9-OTA Fund Development Committee, OTA Nominating Committee, AAOS Subcommittee on Trauma)	Paper #106; Posters #17, 67
Altman, Greg . . . . . (n) . . . . .	Moderator, Lab Faculty
Alxerad, Thomas W. . . . . (n) . . . . .	Poster #77

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Amsdell, Simon Levi	(n)	Paper #35
Anders, Mark J.	(2-DePuy, A Johnson & Johnson Company, Synthes,(AO), 4-Johnson & Johnson, Stryker, 9-Orthopaedic Trauma Association)	Paper #98; Poster #154 Lab Faculty
Andersen, Clark	(n)	Posters #45, 49
Andersen, Romney C.	(9-Orthopaedic Trauma Association, Military Committee)	Posters #68, 92 Mini Symposium Faculty
Anderson, Duane	(n)	Int'l Poster #25
Anderson, Lucas	(n)	Int'l Poster #25
Andreychik, Cassandra M.	(n)	Paper #30
Andruszkow, Hagen	(n)	Poster #148; Int'l Poster #33
Antoci, Valentin	(n)	Poster #50
Appleton, Paul T.	(2-Acumed, LLC, 3B-Acumed LLC)	Papers #33, 44, 72
Archdeacon, Michael T.	(3B-Stryker, 7-SLACK Incorporated, 8-Journal of Bone and Joint Surgery-American; Wolters Kluwer Health - Lippincott Williams & Wilkins, 9-Orthopaedic Trauma Association)	Posters #1, 11 Lab Faculty
Archer, Crystal	(n)	Paper #21
Archer, Kristin	(n)	Poster #116, 122
Armstrong, Tyler J.	(n)	Poster #189
Arrington, John A.	(n)	Paper #115
Assal, M.	(???)	Int'l Poster #35
Athans, Bill	(n)	Paper #85
Athwal, George S.	(5-Arthrex, CONmed Linvatec, Torneir, 8-Journal of Shoulder and Elbow Surgery)	Paper #81
Ayeni, Olufemi	(n)	Poster #23
Ayers, David C.	(n)	Paper #12
Baghel, Kavita	(???)	Int'l Poster #12
Bains, Simrit	(n)	Poster #23
Baker, Adam P.	(n)	Poster #31
Baker, Brett	(3A,4-Microbion Corporation)	Paper #52
Baker, Kevin	(n)	Paper #31
Baldwin, Keith	(n)	Paper #110, Poster #117
Banerjee, Rahul	(9-AAOS; AAOS)	Poster #66
Baptista, Bruno Bellaguarda	(???)	Int'l Posters #3 & 4
Barber, Richard B.	(n)	Poster #141
Barei, David P.	(2-Synthes, 3B-Synthes, 5-Zimmer; Synthes, 9-AO/ASIF)	Poster #37
Barfield, William	(n)	Poster #75
Barnes, Hayley	(n)	Poster #54
Barzyk, Tisha	(n)	Poster #116

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Bates, P. . . . .	(n)	Int'l Poster #22
Bauer, Jennifer M. . . . .	(n)	Posters #34, 185
Bauman, Ryan . . . . .	(n)	Poster #18
Bazylewicz, Dan . . . . .	(n)	Poster #2
Beavers, Bret D. . . . .	(n)	Poster #5
Bechtold, Joan E. . . . .	(3B-IsurTec Zyga Medical, . . . . .	Symposium Moderator
	3C-Twin Star Medical Circle Biologics DGIMed, .	Moderator
	5-DePuy, A Johnson & Johnson Company;	
	National Institutes of Health (NIAMS & NICHD);	
	Smith & Nephew; Synthes; Zimmer; Department	
	of Defense, Armed Forces Institute for Regenerative	
	Medicine, 8-Journal of Biomechanics; Journal of	
	Orthopaedics and Traumatology Journal of	
	Applied Biomechanics, 9-AAOS; Orthopaedic	
	Research Society; World Congress of Biomechanics)	
Bederman, S. Samuel . . . . .	(1-SpineArt 3B-Alphatec Spine; Biomet; Stryker; Paper #103	
	SpineArt 5-Nuvasive 8-BMC Musculoskeletal	
	Disorders; Journal of the Canadian Chiropractic Association)	
Bedigrew, Katherine . . . . .	(n)	Poster #41
Beerekamp, Suzan . . . . .	(n)	Poster #53
Behn, Anthony W. . . . .	(n)	Paper #2
Beimel, C. . . . .	(???)	Int'l Poster #29
Bekele, Segni . . . . .	(n)	Int'l Poster #25
Belkin, Nicole . . . . .	(n)	Paper #14
Bell, Anthony James . . . . .	(4-Oculus Innovative Sciences - . . . . .	Paper #97
	wound/tissue care products)	
Bellabarba, Carlo . . . . .	(8-Journal of Orthopaedic Trauma). . . . .	Poster #166
Bellamy, Jaime . . . . .	(n)	Paper #99
Beltran, Michael J. . . . .	(n)	Poster #183
Bemenderfer, Thomas . . . . .	(n)	Paper #9
Benirschke, Stephen K. . . . .	(3C-Synthes; Zimmer) . . . . .	Poster #37
Bennett, Ryan E. . . . .	(n)	Poster #12
Berber, Reshid . . . . .	(n)	Paper #36; Poster #86
Berkes, Marschall B. . . . .	(n)	Papers #90, 119; Posters #14, 38, 48,
		56, 77, 84, 95, 171
Bernstein, Joseph . . . . .	(8-CORR deputy editor-receive stipend) . . . . .	Posters #25, 135
Bernstein, Mitchell . . . . .	(n)	Poster #133
Betts, Robert . . . . .	(n)	Paper #100
Bevevino, Adam James . . . . .	(n)	Posters #168, 169
Beyth, Shaul . . . . .	(n)	Int'l Poster #10
Bhagwat, Kishan R. . . . .	(n)	Poster #192

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- Bhandari, Mohit . . . . . (3B-Amgen Co; Eli Lilly; Stryker; Smith . . . Posters #23, 146 & Nephew; Zimmer; . . . . . Int'l Poster #34, 5-Smith & Nephew; DePuy, . . . . . Moderator, A Johnson & Johnson Company) . . Symposium Moderator, . . . . . Symposium Faculty, . . . . . Mini Symposium Faculty
- Bible, Jesse . . . . . (n) . . . . . Poster #34, 58, 179, 185, 187
- Bihari, Relka . . . . . (n) . . . . . Paper #50
- Bishop, Julius A. . . . . (2-Synthes, 5-Zimmer) . . . . . Paper #2; Poster #134
- Bissing, David . . . . . (n) . . . . . Poster #174
- Bitar, Rogério Carneiro . . . . . (???) . . . . . Int'l Poster #5
- Blachut, Piotr . . . . . (n) . . . . . Poster #63
- Black, Eric . . . . . (n) . . . . . Poster #50
- Black, Mary Helen . . . . . (n) . . . . . Paper #77
- Black, Sheena . . . . . (n) . . . . . Poster #144
- Blair, James A. . . . . (n) . . . . . Poster #91
- Blaisdell, Gregory Y. . . . . (n) . . . . . Paper #59
- Blanck, Ryan . . . . . (n) . . . . . Poster #44
- Blease, Robert E. . . . . (n) . . . . . Poster #91
- Bledsoe, Gary . . . . . (n) . . . . . Paper #55; Poster #74
- Blomerg, Joshua . . . . . (n) . . . . . Poster #35
- Blomfeldt, Richard . . . . . (n) . . . . . Paper #29
- Bogdan, Yelena . . . . . (n) . . . . . Papers #9, 45
- Bogner, Eric . . . . . (n) . . . . . Poster #171
- Bone, Lawrence B. . . . . (9-COTA) . . . . . Paper #98; Poster #154
- Boone, Christopher . . . . . (n) . . . . . Paper #31
- Born, Christopher T. . . . . (3B-Stryker; Illuminoss, 3C,4-Biointraface, . . . . . Paper #4; 4-Illuminoss, 5-Stryker, 8-Journal of the . . . . . Poster #19 American Academy of Orthopaedic Surgeons; Clinical Orthopaedics and Related Research; Journal of Orthopaedic Trauma; Journal of Trauma, 9-American College of Surgeons; Orthopaedic Trauma Association; AAOS; Foundation for Orthopaedic Trauma)
- Borrelli, Joseph, Jr. . . . . (3B-Regeneration . . . . . Moderator Technologies, Inc., 7-Elsevier . . . . . Symposium Moderator - Injury (Journal); Springer)
- Bosse, Michael J. . . . . (4-Orthopaedic Implant Company; Papers #63, 101, 117, 118; 9-Orthopaedic Trauma Association) . . . . . Poster #149
- Boudreau, John A. . . . . (n) . . . . . Posters #70, 184
- Bougherara, Habiba . . . . . (n) . . . . . Paper #5
- Boulton, Christina L. . . . . (n) . . . . . Poster #131

**Disclosure:**

(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. \* = Not available at time of printing. Refer to pages 620 - 622.



## DISCLOSURE LISTING – ALPHABETICAL

Boutris, Nickolas	(n)	Poster #49
Bowen, Thomas R.	(n)	Paper #30; Poster #21
Bowman, Ariel	(n)	Poster #160
Boyd, Alyse	(n)	Paper #9
Braaksma, William	(n)	Poster #88
Bradford, Anna N.	(n)	Poster #139
Brady, Megan	(n)	Poster #110
Bramlett, Kasey	(n)	Poster #16
Brasher, Penny	(n)	Poster #30
Bray, Christopher	(n)	Poster #170
Bray, Timothy J.	(3C,4-Anthem Orthopaedics, 4-Orthopaedic Implant Company, 6-Smith & Nephew, Renown Regional Medical Center Institutional, Trauma Fellowship Support, Stryker, 8-Orthopaedic Trauma Association, 9-Orthopaedic Trauma Association Board of Directors)	Paper #106; Posters #17, 67; OTA Board; Mini Symposium Faculty
Breederveld, Roelf	(n)	Poster #85
Brennan, Kindyle L.	(n)	Poster #26
Brennan, Michael L.	(n)	Poster #26
Brey, Jennifer	(n)	Poster #176
Briant-Evans, Toby	(2-I received a single consulting fee from Biomet; 3A-My wife was employed on a temporary contract by Stryker as a clinical nurse consultant between March and June 2011 in New Zealand.)	Poster #182
Brighton, Brian K.	(n)	Posters #170, 174
Brinker, Mark R.	(3B-Biomet, 5-Synthes, 7-Saunders/Mosby- Elsevier, 8-Journal of Orthopaedics and Traumatology)	Poster #181
Brinkmann, Elyse	(n)	Paper #32
Britton, Edward	(n)	Int'l Poster #22
Broderick, J. Scott	(2-AONA, 3B-Zimmer, 9-Orthopaedic Trauma Association; South Carolina Orthopaedic Association)	Case Presentation Faculty
Brown, Andrew K.	(n)	Poster #100
Brown, Gavin	(n)	Poster #28
Brown, Timothy	(n)	Poster #144
Bruce, Brandon T.	(n)	Poster #112
Budsberg, Steven C.	(2-Pfizer; Novartis, 3B-Norvartis, Merial, 5-Merial)	Paper #76
Bugler, Kate Ella	(n)	Papers #39, 40, 44, 84; Posters #57, 107
Buijze, Geert A.	(n)	Paper #93; Poster #102

**Disclosure:**

(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. \* = Not available at time of printing. Refer to pages 620 - 622.

## DISCLOSURE LISTING – ALPHABETICAL

- Bukata, Susan V. . . . . (2-Amgen Co; Eli Lilly; . . . . . Symposium Faculty  
*Norvoartis, 3B-Amgen Co; Eli Lilly; Merck,*  
*5-Amgen Co; Eli Lilly, 9-Bone and Joint Decade, U.S.A.*  
*ASBMR professional practice committee)*
- Bunn, Duong . . . . . (n) . . . . . Lab Faculty
- Burgess, Andrew R. . . . . (2,3B,4-Stryker) . . . . . Symposium Faculty
- Burgkart, Rainer . . . . . (3B,5-Stryker Trauma GmbH, Kiel) . . . . . Posters #15, 24
- Burns, Travis C. . . . . (n) . . . . . Poster #186
- Buyea, Cathy M. . . . . (n) . . . . . Paper #98; Poster #154
- Canet, Fanny . . . . . (n) . . . . . Poster #98
- Canet, Fanny, Jr. . . . . (n) . . . . . Paper #81
- Cannada, Lisa K. . . . . (2-Smith & Nephew, 3B,5-Zimmer; . . . . . Papers #32, 68, 69;  
*Synthes; Department of Defense; . . . . . Posters #54, 113, 174*  
*Southeast Fracture . . . . . Mini Symposium Moderator,*  
*Consortium, 8-Journal of . . . . . Mini Symposium Faculty*  
*Orthopaedic Trauma; Journal of Traumatology; . OTA Board*  
*Orthopedics Today; Journal of Bone and Joint*  
*Surgery - American; Clinical Orthopaedics*  
*and Related Research; Current Orthopaedic Practice;*  
*Geriatric Surgery and Rehabilitation,*  
*9-AAOS; Orthopaedic Trauma Association;*  
*Ruth Jackson Orthopaedic Society)*
- Cantu, Robert Victor . . . . . (n) . . . . . Paper #96; Poster #82
- Carlberg, Kelly . . . . . (n) . . . . . Paper #31
- Carlini, Anthony R. . . . . (n) . . . . . Paper #117, 118; Poster #139
- Carlisle, Hope . . . . . (n) . . . . . Paper #25
- Carmack, David B. . . . . (2-AO (I teach at AO courses, . . . . . Lab Faculty  
*technically not an implant company),*  
*8-Journal of Trauma (non paid reviewer),*  
*9-OTA Health Policy Committee)*
- Carr, Brendan G. . . . . (n) . . . . . Poster #143
- Carroll, Eben A. . . . . (5,6-Synthes; Smith & Nephew). . . . . Poster #158
- Carsen, Sasha . . . . . (n) . . . . . Paper #70
- Cartner, Jacob . . . . . (3A-Smith & Nephew, . . . . . Paper #6  
*9-Orthopaedic Research Society)*
- Casey, Virginia . . . . . (n) . . . . . Poster #174
- Cashman, J. . . . . (???) . . . . . Int'l Poster #27

**Disclosure:**

(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. \*= Not available at time of printing. Refer to pages 620 - 622.

## DISCLOSURE LISTING – ALPHABETICAL

Cass, Joseph R. ....	(2-Synthes. Book received for acting as a faculty . . . . .	Paper #19; at one of their instructional meetings., . . . . .	Poster #188 4-Johnson & Johnson; Johnson & Johnson, 6-Our department receives support from multiple companies. I do not personally receive support from any company. 9-Orthopaedic Trauma Association; AAOS)
Casstevens, Chris . . . . .	(n) . . . . .		Poster #11
Casteulani, Alberto Cid . . . . .	(n) . . . . .		Posters #7, 159
Castiglia, Marcelo . . . . .	(???) . . . . .		Int'l Poster #4
Castillo, Renan . . . . .	(n) . . . . .	Papers #34, 57, 67, 117, 118; . . . . .	Posters #122, 127, 138, 139
Castillo, Tiffany . . . . .	(n) . . . . .		Paper #2
Caswell, Kathleen . . . . .	(n) . . . . .		OTA Executive Director
Cathcart, Curtis . . . . .	(n) . . . . .		Paper #76
Cepinskas, Gediminas . . . . .	(n) . . . . .		Paper #50
Chakraverty, Rajesh . . . . .	(n) . . . . .		Poster #23
Chala, Abebe . . . . .	(n) . . . . .		Int'l Poster #25
Chan, Daniel S. . . . .	(n) . . . . .		Poster #162
Chan, Holman . . . . .	(n) . . . . .	Papers #35, 100; Poster #147	
Chaput, Christopher D. . . . .	(3C-Facet- Link, 5-Medtronic, Globus, . . . . .		Poster #26 SpineSmith, Nuvasive, 6-Facet-Link)
Chechik, Ofir . . . . .	(n) . . . . .		Poster #4
Chen, Antonia F. . . . .	(n) . . . . .		Poster #8
Chen, Gary . . . . .	(n) . . . . .		Int'l Poster #21
Cheung, Tung . . . . .	(n) . . . . .		Poster #85
Chiavaras, Meg . . . . .	(n) . . . . .		Poster #23
Cho, Mickey S. . . . .	(n) . . . . .		Poster #91
Choi, Lisa . . . . .	(n) . . . . .		Poster #8
Choma, Theodore . . . . .	(2, 3B-Stryker, 4-Gentis, Inc, 5-DePuy, . . . . .		Paper #16 A Johnson & Johnson Company; Stryker, 9-Scoliosis Research Society)
Choudhry, Imran K . . . . .	(n) . . . . .		Poster #177
Choudur, Hema . . . . .	(n) . . . . .		Poster #23
Choxi, Ankeet A. . . . .	(n) . . . . .	Posters #34, 58, 179, 187	
Christiano, Anthony . . . . .	(n) . . . . .		Poster #32
Clement, Nicholas David . . . . .	(n) . . . . .	Paper #84; Posters #57, 97, 107; . . . . .	Int'l Posters #26 & 30
Clement, Rutledge Carter . . . . .	(n) . . . . .		Posters #25, 143
Clinton, Rebecca . . . . .	(n) . . . . .		Paper #67
Cody, John P. . . . .	(n) . . . . .		Posters #168, 169
Cole, Ashley L. . . . .	(n) . . . . .		Paper #76; Poster #180

**Disclosure:**

(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. \*= Not available at time of printing. Refer to pages 620 - 622.

## DISCLOSURE LISTING – ALPHABETICAL

- Cole, Peter A. . . . . (3B-Synthes <\$10k/year); 5-Synthes). . . . . Paper #86;  
. . . . . Posters #87, 96;  
. . . . . Case Presentation Faculty
- Colen, Robert . . . . . (n) . . . . . Poster #88
- Coll, Daniel John . . . . . (4-Merck). . . . . Paper #106;  
. . . . . Posters #17, 67
- Collinge, Cory A. . . . . (1-Biomet; Smith & Nephew; Advanced. . . . . Papers #9, 73;  
Orthopedic Solutions, Synthes, . . . . . Posters #1, 13, 183  
3B-Biomet and Smith&Nephew, . . . . . Lab Moderator,  
8-Journal of Orthopaedic . . . . . Mini Symposium Faculty  
Trauma, 9-Foundation for Orthopedic Trauma) . EBM Poster
- Colman, Matthew . . . . . (n) . . . . . Poster #8
- Comer, Gareth . . . . . (n) . . . . . Poster #134
- Cormier, Maria . . . . . (n) . . . . . Paper #21
- COTS (Canadian. . . . . (n) . . . . . Paper #91  
Orthopaedic Trauma Society)
- Court-Brown, Charles M. . . . . (7-Wolters Kluwer Health - . . . . . Papers #44, 74, 84, 92;  
Lippincott Williams & Wilkins, . . . . . Posters #57, 97;  
8-Journal of Bone and Joint . . . . . Int'l Posters #26 & 30  
Surgery - British)
- Crawford, Adam C. . . . . (n) . . . . . Poster #51
- Crawford, Alvin H. . . . . (3C-DePuy, A Johnson and Johnson Company, . . . . . Poster #177  
5-OREF, 9-J. Robert Gladden Society)
- Creevy, William R. . . . . (n) . . . . . Mini Symposium Moderator,  
. . . . . Case Presentation Moderator
- Crist, Brett D. . . . . (2-Synthes, 3B-KCI; Medtronic, . . . . . Paper #16, 104;  
4-Amedica Corporation; Orthopaedic . . . . . Posters 51, 52, 125  
Implant Company, 5-Medtronic; Sonoma;  
Synthes; Wound Care Technologies, 6-DePuy,  
A Johnson & Johnson Company; Zimmer,  
8-Journal of Orthopaedic Trauma; Journal of the  
American Academy of Orthopaedic Surgeons;  
Your Orthopaedic Connection,  
9-Orthopaedic Trauma Association)
- Cross, Michael Brian . . . . . (n) . . . . . Poster #77
- Cross, William Wood . . . . . (2-Synthes, AO North America, . . . . . Papers #19, 66;  
3B-Innovative Medical Device Solutions) . . . . . Poster #188
- Crossett, Lawrence S. . . . . (n) . . . . . Poster #8
- Culpan, P. . . . . (n) . . . . . Int'l Poster #22
- Cunningham, Brian P. . . . . (n) . . . . . Paper #24
- Currie, Colin . . . . . (???) . . . . . Poster #27
- Curry, Michael Cody . . . . . (n) . . . . . Poster #45

**Disclosure:**

(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. \* = Not available at time of printing. Refer to pages 620 - 622.

## DISCLOSURE LISTING – ALPHABETICAL

Cymerman, Rachel M. . . . . (n) . . . . .	Posters #38, 56
D’Alleyrand, Jean-Claude G. . . . . (n) . . . . .	Poster #68
Dahn, Uwe . . . . . (n) . . . . .	Paper #28
Dailey, Tyler A. . . . . (n) . . . . .	Poster #51
Daley, James . . . . . (n) . . . . .	Poster #123
Daly, Charles . . . . . (n) . . . . .	Poster #75
Daly, Michael Christopher . . . . . (n) . . . . .	Paper #103
Daniels, Marissa . . . . . (n) . . . . .	Poster #144
Das, Ashim . . . . . (n) . . . . .	Poster #192
Datta, Neil . . . . . (n) . . . . .	Paper #41
Daubs, Gregory M. . . . . (n) . . . . .	Paper #107
Davenport, Daniel L. . . . . (n) . . . . .	Poster #112
Davidovitch, Roy . . . . . (3B-Mako Surgical). . . . .	Posters #78, 79, 80, 83
Davies, Jonah . . . . . (n) . . . . .	Paper #46
Davis, William T . . . . . (n) . . . . .	Poster #145
Dayer, R. . . . . (???) . . . . .	Int’l Poster #35
Deafenbaugh, Brad . . . . . (n) . . . . .	Paper #78
de Ridder, Victor A. . . . . (n) . . . . .	Moderator; OTA Committee
Deakin, Dan E. . . . . (n) . . . . .	Poster #136
DeBritz, James N. . . . . (n) . . . . .	Poster #115
Deger, Tina . . . . . (n) . . . . .	Paper #13
Dehghan, Niloofar . . . . . (n) . . . . .	Poster #29
DelaRocha, Adriana . . . . . (n) . . . . .	Poster #175
Della Rocca, Gregory J. . . . . (2-Synthes, 3B-Medtronic; LifeNet Health, .	Papers #16, 104;
4-Amedica; The Orthopaedic . . . . .	Posters #51, 52, 125, 146
Implant Company, 5-Wound Care Technologies;	
Eli Lilly; Sonoma Orthopaedics, 8-Journal of Bone	
and Joint Surgery - American; Journal of Orthopaedic	
Trauma; Journal of the American Academy of	
Orthopaedic Surgeons, 9-AAOS;	
Orthopaedic Trauma Association)	
Derksen, Robert Jan . . . . . (n) . . . . .	Poster #85
Desai, Pratik . . . . . (n) . . . . .	Paper #97
Desy, Nicholas M. . . . . (n) . . . . .	Poster #133
Devore, David I. . . . . (3B,4-Gentis, Inc., Wayne, PA) . . . . .	Paper #21
Dhulipala, Sravan C. . . . . (n) . . . . .	Posters #179, 187
Dickens, Jonathan F. . . . . (n) . . . . .	Poster #92
Didesch, Jacob . . . . . (n) . . . . .	Poster #22

**Disclosure:**

(n) = Respondent answered ‘No’ to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. \*= Not available at time of printing. Refer to pages 620 - 622.

## DISCLOSURE LISTING – ALPHABETICAL

DiGiovanni, Christopher W. . . . .	(1-Extremity Medical, Inc., . . . . .	Poster #191
	2,3B,4-Biomimetic Extremity Medical, Inc.,	
	5-Biomimetic, 6-Curamedix, Inc. Performance	
	Orthotics, Inc., 4-Saunders Elsevier, 8-Foot and	
	Ankle International Techniques in Foot and Ankle Surgery	
	(European) Journal of Foot and Ankle Surgery)	
DiPasquale, Thomas G. . . . .	(1-Biomet, 2-Synthes; Smith & Nephew, . . . . .	Paper #115
	3C-Stryker; Synthes, 5-Stryker, 7-BioMet,	
	9-AOAO Board of Directors)	
Dirrachs, Timm. . . . .	(5-Stryker). . . . .	Int'l Poster #16
Diwan, Amna . . . . .	(n) . . . . .	Paper #61
Doarn, Michael . . . . .	(n) . . . . .	Poster #183
Dollahite, Henry . . . . .	(???) . . . . .	Poster #183
Dombroski, Derek G. . . . .	(n) . . . . .	Poster #151
Donegan, Derek J. . . . .	(n) . . . . .	Lab Faculty
Doornberg, Job . . . . .	(n) . . . . .	Paper #93
Dopkn, Derek . . . . .	(n) . . . . .	Paper #14
Doro, Christopher J. . . . .	(n) . . . . .	Paper #51; Poster #35
Dosanjh, Sonia . . . . .	(n) . . . . .	Poster #146
Dougherty, Paul J. . . . .	(8-Clinical Orthopaedics . . . . .	Mini Symposium Faculty
	and Related Research)	
Drake, Matthew . . . . .	(n) . . . . .	Paper #47
Dubina, Andrew . . . . .	(n) . . . . .	Paper #75
Duckworth, Andrew D. . . . .	(7-Elsevier) . . . . .	Papers #74, 84, 92;
	. . . . .	Posters #97, 107;
	. . . . .	Int'l Poster #30
Dudda, Marcel . . . . .	(n) . . . . .	Int'l Poster #28
Dulaney-Cripe, Elizabeth . . . . .	(n) . . . . .	Poster #18
Dunbar, Robert P., Jr. . . . .	(2-Synthes, 5-Smith & Nephew, 6-Innovision; . . .	Poster #37
	Synthes; Zimmer, 8-Journal of Orthopaedics	
	and Traumatology; OrthoInfo,	
	9-Orthopaedic Trauma Association)	
Duran, J. Armenter . . . . .	(???) . . . . .	Int'l Poster #35
Dyer, George S. . . . .	(n) . . . . .	Paper #83
Dyke, Jonathan P. . . . .	(n) . . . . .	Posters #9, 77
Dziadosz, Daniel . . . . .	(2-Synthes) . . . . .	Paper #48
Earles, Melissa . . . . .	(n) . . . . .	Poster #174
Eastman, Jonathan G. . . . .	(n) . . . . .	Posters #37, 71

**Disclosure:**

(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. \*= Not available at time of printing. Refer to pages 620 - 622.

## DISCLOSURE LISTING – ALPHABETICAL

Egol, Kenneth A. . . . .	(1-Exactech, Inc, 4-Johnson & . . . . . Papers #9, 11, 71, 82; Johnson, 5-Stryker; . . . . . Posters #2, 40, 78, 79, 80, 83, 161 Synthes; OREF, 7-SLACK . . . . . Symposium Faculty Incorporated; Wolters Kluwer Health - Lippincott Williams & Wilkins, 8-Journal of Orthopaedics and Traumatology)
Ehrenfeld, Jesse E. . . . .	(n) . . . . . Posters #43, 109, 124, 129, 189
Ehrlichman, Lauren K. . . . .	(n) . . . . . Poster #47
Eismann, Emily A. . . . .	(n) . . . . . Poster #177
Eismont, Frank . . . . .	(3B,4- <i>Alphatec Spine</i> , . . . . . Papers #1, 56 7- <i>Saunders/Mosby-Elsevier</i> )
Elias, Koby . . . . .	(3A,4- <i>Semprus Biosciences</i> ) . . . . . Paper #22
Ellington, John Kent . . . . .	(n) . . . . . Poster #47
Elliott, Winston . . . . .	(n) . . . . . Paper #18
Ellis, Scott J. . . . .	(n) . . . . . Poster #157
Elmaraghy, Amr . . . . .	(???) . . . . . Poster #90
Enocson, Anders G. . . . .	(n) . . . . . Paper #29
Erli, Hans-Josef . . . . .	(???) . . . . . Poster #108
Eshed, Iris. . . . .	(n) . . . . . Int'l Poster #20
Espehaug, Birgitte . . . . .	(n) . . . . . Paper #27
Esposito, John . . . . .	(n) . . . . . Poster #104
Esquivel, Amanda . . . . .	(n) . . . . . Poster #69
Evans, Jason M. . . . .	(n) . . . . . Posters #58, 64, 149, 179, 187
Fabricant, Peter D. . . . .	(n) . . . . . Poster #171
Falcone, Richard. Jr. . . . .	(???) . . . . . Mini Symposium Faculty
Fanelli, Gregory C. . . . .	(2- <i>Biomet</i> , 7- <i>Sports Medicine</i> . . . . . Mini Symposium Faculty and <i>Arthroscopy Review</i> , 7,8- <i>Wolters Kluwer Health - Lippincott Williams &amp; Wilkins</i> )
Fanning, Paul Joseph . . . . .	(n) . . . . . Paper #12
Farrell, Dana J. . . . .	(n) . . . . . Posters #155, 190
Feibel, Robert J. . . . .	(n) . . . . . Paper #70
Feldman, Debbie . . . . .	(n) . . . . . Poster #132
Fernandez, Diego L. . . . .	(3B- <i>Biomet Toby Orthopaedics Martin</i> , . . . . . Poster #102 3C- <i>Synthes</i> )
Fevang, Jonas . . . . .	(n) . . . . . Paper #27
Firman, Eliseo . . . . .	(n) . . . . . Posters #7, 159
Firoozabadi, Reza . . . . .	(n) . . . . . Poster #37
Fischer, J. . . . .	(n) . . . . . Int'l Poster #33
Fishler, Thomas . . . . .	(n) . . . . . Poster #137
Fitzgibbons, Peter . . . . .	(n) . . . . . Paper #109
Fleming, Mark . . . . .	(n) . . . . . Poster #68
Flynn, Jeffery . . . . .	(n) . . . . . Paper #23

**Disclosure:**

(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. \* = Not available at time of printing. Refer to pages 620 - 622.

## DISCLOSURE LISTING – ALPHABETICAL

Flynn, John M. . . . .	(1-Biomet, 7-Wolters Kluwer Health - . . . . . Paper #110 Lippincott Williams & Wilkins, 8-Orthopedics Today, 9-Pediatric Orthopaedic Society of North America; Scoliosis Research Society; AAOS)
Flynn, Sean . . . . .	(n) . . . . . Poster #65
Ford, Gregory . . . . .	(n) . . . . . Poster #142
Forman, Jordanna M. . . . .	(n) . . . . . Posters #40, 79, 161
Foroohar, Abtin . . . . .	(n) . . . . . Poster #176
Forward, Daren P. . . . .	(n) . . . . . Paper #37; Poster #86; . . . . . Int'l Poster #17
Fowler, A. . . . .	(n) . . . . . Int'l Poster #17
Fragomen, Austin T. . . . .	(1-Small Bone Innovations, . . . . . Poster #157 2,3B,5-Smith & Nephew)
Franco, Dennis P. . . . .	(n) . . . . . Paper #88
Freedman, Brett A. . . . .	(n) . . . . . Paper #76; Poster #180
Freiss, Darin . . . . .	(3B-Acumed, LLC) . . . . . Case Presentation Moderator
French, Bruce G. . . . .	(2-Synthes, 3B-Biomet, . . . . . Poster #152 8-Journal of Orthopedic Trauma)
Frick, Steven L. . . . .	(9-American Orthopaedic Association;. . . Posters #170, 174 J. Robert Gladden Society; . . . . Mini Symposium Faculty Pediatric Orthopaedic Society of North America)
Friday, Maranda N. . . . .	(n) . . . . . Poster #155
Friedberg, David A. . . . .	(2-Synthes, 3B-Synthes) . . . . . Paper #88
Frink, Michael . . . . .	(n) . . . . . Poster #148; . . . . . Int'l Poster #33
Fu, Guo . . . . .	(n) . . . . . Int'l Poster #21
Fulkerson, Eric W. . . . .	(???) . . . . . Lab Faculty
Fuller, David . . . . .	(n) . . . . . Poster #100
Furey, Andrew . . . . .	(n) . . . . . Poster #105
Furman, Bridgette D. . . . .	(n) . . . . . Paper #49
Galat, Daniel . . . . .	(n) . . . . . Int'l Poster #6
Gallimore, Christopher . . . . .	(n) . . . . . Paper #5
Gammon, Steve R. . . . .	(n) . . . . . Poster #12
Gamulin, Axel . . . . .	(???) . . . . . Int'l Poster #35
Gandhi, Rajiv . . . . .	(n) . . . . . Paper #15

**Disclosure:**

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## DISCLOSURE LISTING – ALPHABETICAL

Gardner, Michael J. . . . .	(3B-Synthes; DGIMed; Amgen Co; Stryker; . . . . Paper #73; RTI Biologics, 5-Synthes; . . . . . Posters #22, 60, 164, 165 Amgen Co, 7-Wolters Kluwer Health - . . . . . Moderator, Lippincott Williams & - . . . . . Symposium Faculty, Wilkins, 9-Orthopaedic . . . . Case Presentation Moderator, Trauma Association) . . . . . Case Presentation Faculty; . . . . . OTA Committee
Gardner, Stephen T. . . . .	(n) . . . . . Paper #33
Garrett, Jeffrey P. . . . .	(n) . . . . . Poster #10
Gaski, Greg . . . . .	(n) . . . . . Paper #57
Gaston, R. Glenn . . . . .	(1,3B-Biomet, 3B,4-MiMedx, 8-Journal of Hand Surgery Am., Journal of Hand and Microsurgery, Yearbook of Hand Surgery, 9-ASSH: Clinical Trials and Outcomes Committee, Young Members Steering committee). . . . . Poster #174
Gauger, Erich M. . . . .	(n) . . . . . Paper #86
Gausepohl, Thomas . . . . .	(2,3B,4-IlluminOss) . . . . . Int'l Poster #8
Geßmann, J. . . . .	(n) . . . . . Int'l Poster #28
Geerts, William H. . . . .	(2-Pfizer; Sanofi-Aventis; . . . . . Moderator, Bayer Healthcare, . . . . . Symposium Moderator, 3B-Pfizer; Bayer Healthcare, 6-Pfizer; . . Symposium Faculty Sanofi-Aventis; Bayer Healthcare; Boehringer-Ingelheim)
Gettys, Franklin K. . . . .	(n) . . . . . Paper #79
Getz, Stanley . . . . .	(n) . . . . . Paper #101
Giannoudis, Peter V. . . . .	(1-Johnson & Johnson, 2, 3B,5-DePuy, . . . . . Poster #118 A Johnson & Johnson Company; . . . . . Int'l Poster #18 Stryker; Synthes; 2-Eli Lilly; Medtronic Sofamor Danek, 3C,5-Amgen Co, 7-Injury Journal, 8-BMC Musculoskeletal Disorders, Injury, Journal Orthopaedic Trauma, European Journal of Trauma, Open Journal of Orthopaedics, Expert Opinion on Drug Safety; Springer, 9-Orthopaedic Trauma Association. British Trauma Society, British Orthopaedic Association; European Federation of National Associations of Orthopedics and Traumatology)
Gilde, Alex . . . . .	(n) . . . . . Poster #87
Gillespie, Bryce . . . . .	(n) . . . . . Paper #83
Gitajn, Ida Leah . . . . .	(n) . . . . . Posters #42, 46
Gjertsen, Jan-Erik . . . . .	(n) . . . . . Paper #27
Glaser, Sheri . . . . .	(n) . . . . . Poster #144

**Disclosure:**

(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. \*= Not available at time of printing. Refer to pages 620 - 622.

## DISCLOSURE LISTING – ALPHABETICAL

Glott, Thomas	(n)	Paper #62
Goetz, Jessica	(n)	Paper #17
Gofton, Wade	(n)	Poster #178
Gold, Stuart M.	(2,3B,5-Smith & Nephew; Stryker, 5-Synthes; Zimmer)	Paper #77
Golden, Robert D.	(n)	Poster #115
Gollogly, Jim.	(n)	Int'l Poster #31
Goni, Vijay G.	(n)	Poster #192
Gonser, Christoph	(n)	Int'l Poster #14
González del Pino, Juan	(n)	Poster #102
Goodman, Mark A.	(n)	Poster #8
Gorczyca, John T.	(8-The Journal of Orthopaedic Trauma; . . . and The Journal of Trauma, Injury, . . . . . Infection and Critical Care, . . .Mini Symposium Moderator, 9-AAOS CME Committee). . . . .	Papers #35, 100; Poster #147 Case Presentation Faculty
Gordon, J. Eric	(1,3B-Orthopediatrics, . . . . .	Case Presentation Faculty 9-Pediatric Orthopaedic Society of North America)
Gordon, Wade T.	(n)	Poster #68
Gore, Abbey	(n)	Poster #115
Goslings, J. Carel	(n)	Paper #93; Poster #53
Got, Christopher	(n)	Paper #109
Gothard, Michael D.	(n)	Paper #112
Gottschling, Heiko	(n)	Poster #24
Goulet, James A.	(1-Zimmer, 2-Smith & Nephew, . . . . . 4-Pioneer Surgical Technology, . . . . . 9-American Orthopaedic . . . . . Association; Orthopaedic . . . . . Trauma Association; . . . . . Michigan Orthopaedic Society)	Papers #58, 60; Poster #61 Moderator, Symposium Moderator, Mini Symposium Moderator; OTA Board; OTA Committee
Goyal, Kanu	(n)	Posters #62, 65
Gradl, Gertraud	(5-Stryker).	Int'l Posters #13 & 16
Graham, Jove	(n)	Poster #21
Grana, William A.	(8-American Journal of Orthopaedics, . . . . . Associate Editor. Othopaedic Knowledge Online, Editor in Chief)	Poster #81
Grant, Kevin	(n)	Paper #31
Graves, Matt L.	(2, 3B,5-Synthes, 5-Stryker, . . . . . 8-Journal of Orthopaedic Trauma, 9-Orthopaedic Trauma Association Education Committee)	Paper #32
Graves, Sara	(n)	Paper #96; Poster #82

**Disclosure:**

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## DISCLOSURE LISTING – ALPHABETICAL

Gray, Bridget	..... (n) .....	Paper #111
Gray, Chancellor	..... (8-University of Pennsylvania .....	Paper #14 <i>Orthopaedic Journal)</i>
Gray, Rob	..... (n) .....	Poster #103
Green, Daniel W.	..... (1-Pega Medical, 2-Arthrex, Inc, .....	Poster #171 7-Current Opinion in Pediatrics; 7,8-Wolters Kluwer Health - Lippincott Williams & Wilkins, 9-New York State Society of Orthopaedic Surgeons; New York County Medical Society; Pediatric Orthopaedic Society of North America; Scoliosis Research Society AO Peds Trauma Teaching Faculty)
Greenberg, Alexander	..... (n) .....	Poster #33
Gregory, Dennis	..... (n) .....	Mini Symposium Faculty
Griffin, Sean Michael	..... (n) .....	Paper #63; Poster #149
Grogan, Brian F.	..... (n) .....	Poster #91
Gross, Jonathan M.	..... (3B-Synthes lectured at basic course. ....	Papers #35, 100; for operating personnel) .....
Groth, Adam	..... (n) .....	Poster #147
Gueorguiev, Boyko	..... (n) .....	Paper #47
Gruen, Gary S.	..... (3B-Smith & Nephew) .....	Int'l Posters #14 & 15
Guilak, Farshid	..... (n) .....	Poster #190
Guirguis, Farid	..... (n) .....	Paper #49
Guy, Pierre	..... (3B,5-Stryker, 4-Traumis, 5-Synthes; DePuy, ....	Poster #90 A Johnson & Johnson .....
	..... Moderator;	Company) .....
	..... Mini Symposium Moderator;	OTA Committee
Gyftopoulos, Soterios	..... (n) .....	Poster #80
Hadaway, Scott	..... (n) .....	Poster #18
Hadley, Scott	..... (n) .....	Paper #11
Hagemeister, Nicola	..... (n) .....	Paper #89; Posters #94, 99
Hagon, O.	..... (???) .....	Int'l Poster #35
Hahn, D. M.	..... (n) .....	Int'l Poster #17
Haidukewych, George J.	..... (n) .....	Paper #85; ..... Posters #6, 39, 73; ..... Mini Symposium Faculty
Hak, David J.	..... (3B-RTI Biologics, 4-Emerge, .....	OTA Board 5-Synthes; Stryker, 8-Orthopedics; Journal of Orthopaedic Trauma, 9-Orthopaedic Trauma Association, International Society for Fracture Repair)
Hale, Joseph E.	..... (3B-Paid consultant for .....	Poster #108 Conventus Orthopaedics)

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## DISCLOSURE LISTING – ALPHABETICAL

Halvorson, Jason	(n)	Poster #158
Hameed, Morad	(n)	Poster #150
Hamilton, David	(n)	Posters #59, 112
Hamilton, Thomas William	(n)	Paper #111
Hankenson, Kurt D.	(3B-Venenum, 5-Synthes, 8-Journal of Bone and Mineral Research, 9-Orthopaedic Research Society ACLAM AALAS)	Paper #14
Hanus, Bryan D.	(n)	Poster #181
Hardeski, David P.	(n)	Poster #130
Harris, Mitchel B.	(3B-LRS Ortho- an Israeli start-up company, working on navigational equipment; Harvard Clinical Research INstitute(HCRI), 4-LRS Ortho - 161 shares; HCRI- hourly consultant, 9-North American Spine Society)	Paper #33; Poster #75
Harrison, W. J.	(???)	Int'l Poster #27
Hartsock, Langdon A.	(5-Synthes, 9-Southern Orthopaedic Association)	
Harvey, Edward J.	(5-Synthes; Stryker; Smith & Nephew; Zimmer, 7-Canadian Journal of Surgery, 8-Canadian Journal of Orthopaedic Trauma Association; Canadian Orthopaedic Association; Orthopaedic Research Society)	Poster #133; Moderator; Symposium Moderator
Havelin, Leif Ivar	(n)	Paper #27
Hazanov, Alexander	(n)	Int'l Poster #20
Heard, Wendell M.R.	(n)	Paper #4; Poster #19
Hebert-Davies, Jonah	(n)	Paper #46
Heckert, Reed	(n)	Poster #92
Hedbeck, Carl-Johan	(n)	Paper #29
Hegde, Vishal	(n)	Poster #157
Heins, Sara Elizabeth	(n)	Paper #117; Poster #122, 139
Helfet, David L.	(3C-OHK; Healthpoint Capital; Orthobond; TriMedics; OR International, 4-OHK Medical Devices; FxDevices; Synthes)	Papers #90, 119; Posters #9, 14, 38, 48, 56, 77, 84, 95, 171
Hellund, Johan C.	(n)	Paper #62

**Disclosure:**

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## DISCLOSURE LISTING – ALPHABETICAL

Henley, M. Bradford . . . . .	(1-Zimmer, . . . . . Mini Symposium Faculty, 2-Smith & Nephew; . . . . . Case Presentation Faculty Stryker / Howmedica; Zimmer, 3B-Gerson Lehrman Group; Guidepoint Global; Medical Resource Network; Milliman Care Guidelines; Premera Blue Cross; Providence Health & Services; Zimmer, 3C-DeRoyal; Karen Zupko and Assts; Synergey Surgical (Renovis); Synthes, 4-Renovis (formerly Synergy Surgical Technologies), 7-Wolters Kluwer Health -Lippincott Williams & Wilkins, 8-American Medical Association Publications, 9-AAOS)
Henry, Patrick David George . . (n) . . . . .	Paper #64
Herder, Lindsay . . . . . (n) . . . . .	Paper #72
Herman, Amir . . . . . (n) . . . . .	Int'l Poster #20
Herman, Martin . . . . . (n) . . . . .	Poster #176
Hershkowitz, Oded. . . . . (n) . . . . .	Int'l Poster #20
Herzog, Darren Travis . . . . . (n) . . . . .	Poster #69
Herzog, Mary Alicia . . . . . (n) . . . . .	Poster #172
Higgins, Thomas F. . . . . (n) . . . . .	Paper #107; Poster #55; . . . . . Moderator; Case Presentation Faculty; . . . . . OTA Committee
Hildebrand, Frank . . . . . (n) . . . . .	Poster #148; . . . . . Int'l Poster #33
Hill, Michael . . . . . (n) . . . . .	Posters #62, 65
Hill, Ronald W. . . . . (n) . . . . .	Poster #126
Hiller, Paul . . . . . (n) . . . . .	OTA Staff
Hinojosa, Lauren Nicole . . . . (n) . . . . .	Posters #142, 144
Hirsch, Brandon . . . . . (n) . . . . .	Poster #171
Hitchcock, Robert W. . . . . (n) . . . . .	Poster #55
Ho, Christina A. . . . . (n) . . . . .	Case Presentation Faculty
Ho, Kevin . . . . . (???) . . . . .	Poster #90
Hobby, Jonathan . . . . . (n) . . . . .	Poster #182
Hodson, Emma . . . . . (n) . . . . .	Paper #111
Hoffmann, Martin F. . . . . (n) . . . . .	Paper #116
Holcombe, Sven . . . . . (n) . . . . .	Paper #58; Poster #61
Holley, Jonathan . . . . . (n) . . . . .	Paper #26
Holmes, Ian . . . . . (n) . . . . .	Poster #171
Hon, Shirley . . . . . (n) . . . . .	Paper #107
Hood, Michael . . . . . (n) . . . . .	Paper #104
Hope, Donal . . . . . (n) . . . . .	Poster #168
Hope, Donald . . . . . (n) . . . . .	Poster #169
Horst, Klemens . . . . . (n) . . . . .	Poster #167

**Disclosure:**

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## DISCLOSURE LISTING – ALPHABETICAL

Horwitz, Daniel S. ....	(1,2,3B-DePuy, A Johnson & Johnson Company, . Paper #30 2,3B-Stryker, 5-Synthes, 8-Wolters Kluwer Health - Lippincott Williams & Wilkins, 9-AAOS Foundation for Orthopaedic Trauma)
Hoshino, C. Max .....	(n) ..... Paper #77
Hoskyns, Martha .....	(n) ..... Poster #20
Houdek, Matt .....	(n) ..... Poster #81
Howard, Daniel .....	(n) ..... Posters #78, 80
Hsu, Joseph R. ....	(5-The Geneva Foundation; Combat ..... Paper #99; Casualty Care Research Program; .. Posters #41, 44, 91, 186 The Major Extremity Trauma Research Consortium (METRC), 9-Society of Military Orthopaedic Surgeons, BOD; Limb Lengthening Research Society, BOD; Orthopaedic Trauma Association, Military Committee; The Major Extremity Trauma Research Consortium (METRC), Executive Committee; Skeletal Trauma Research Consortium (STRcC), Director; AAOS, BOS Research Committee)
Hswen, Yulin .....	(n) ..... Poster #82
Hubbard, David F. ....	(2,3B,5-Synthes) ..... Lab Faculty
Huber, Florian G. ....	(2-Synthes) ..... Posters #1, 183
Hubert, Zachary T. ....	(n) ..... Poster #26
Huebner, Janet L. ....	(n) ..... Paper #49
Hui, Emily .....	(6-Smith & Nephew) ..... Paper #34
Humphrey, Catherine A. ....	(n) ..... Papers #35, 100; Poster #147
Hung, Man .....	(n) ..... Paper #107
Hunter, James .....	(???) ..... Paper #7
Huston, Kellen .....	(n) ..... Paper #69
Hutchings, Lynn .....	(n) ..... Paper #111
Hymes, Robert A. ....	(4-Johnson & Johnson) ..... Papers #32, 48, Poster #174
Immerman, Igor .....	(n) ..... Paper #82
Inngul, Christian .....	(n) ..... Paper #29
Iorio, Richard .....	(9-New England Orthopaedic Society ..... Poster #16 (President), Knee Society (Board Member), AAHKS Health Care Policy Committee Member, Editorial Reviewer for Journal of Bone and Joint Surgery, Clinical Orthopaedics and Related Research, Journal of Arthroplasty, Advisory Panel for Cadence)
Irgit, Kaan Suleyman .....	(n) ..... Paper #30; Poster #21
Irrgang, James J. ....	(n) ..... Poster #190
Iserson, Kenneth V. ....	(n) ..... Posters #7, 159
Iskander, Kendra .....	(n) ..... Paper #41

**Disclosure:**

(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. \* = Not available at time of printing. Refer to pages 620 - 622.

## DISCLOSURE LISTING – ALPHABETICAL

Israel, Heidi	(n)	Poster #120
Issar, Neil M.	(n)	Poster #116
Jackson, J. Benjamin, III	(n)	Poster #170
Jackson, Keith L.	(n)	Poster #180
Jackson, Nancy	(n)	Paper #23
Jacobson, Aaron	(n)	Paper #86; Posters #87, 96
Jahangir, A. Alex	(9-Orthopaedic Trauma Association)	Posters #43, 109, 124, 126, 128, 129, 145, 189; Mini Symposium Faculty
Janssen, Heye	(5-Stryker)	Poster #24
Jansson, Karl-Åke PhD.	(n)	Int'l Poster #19
Jawa, Andrew	(n)	Paper #95
Jenkins, Paul J.	(n)	Poster #97
Jenkins, Tyler	(n)	Poster #52
Jenkinson, Richard J.	(n)	Papers #64, 80
Jerabek, Seth	(n)	Paper #33
Jeray, Kyle J.	(2-AONA/Synthes, 3B-Zimmer, 4-Emerge, 5-Synthes, 7-Journal of Bone and Joint Surgery - American, 8-Journal of Orthopaedic Trauma, 9-AAOS; American Orthopaedic Association; Orthopaedic Trauma Association; South Carolina Orthopedic Association)	Poster #174; Moderator; Mini Symposium Faculty
Jin, Xin	(n)	Poster #69
Jinnah, Riyaz H.	(1,2,3B,5-Wright Medical Technology, Inc, 2,3B,5-Mako Surgical, 5-Smith&Nephew, 8-Journal of Surgical Orthopaedic Advances)	Poster #158
Jo, Mark	(n)	Poster #22
Johal, Herman S.	(n)	Paper #105
Johnson, Anne H.	(n)	Poster #50
Johnson, Anthony E.	(2-Pfizer, 8-consultant, orthopaedic devices panel, FDA)	Papers #117, 118
Johnson, Bobby J.	(n)	Poster #11
Johnston, Philip	(???)	Paper #7
Jones, Clifford B.	(8-JBJS, JBJS Trauma Newsletter, Journal of Orthopaedic Trauma, Journal of Trauma, CORR, OCNA, 9-AOA Own the Bone, Association Bylaws Committee, OTA Outcomes and Classification Committee, Michigan Orthopaedic Society President)	Papers #116, 117, 118; Posters #87, 172; Mini Symposium Faculty, Case Presentation Faculty

**Disclosure:**

(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. \* = Not available at time of printing. Refer to pages 620 - 622.

## DISCLOSURE LISTING – ALPHABETICAL

- Jones, David B. . . . . (n) . . . . . Poster #101
- Jordan, Charles . . . . . (n) . . . . . Papers #65, 115
- Judd, Kyle . . . . . (n) . . . . . Posters #64, 113
- Juergens, Christian . . . . . (n) . . . . . Poster #15
- Jupiter, Daniel C. . . . . (n) . . . . . Poster #26
- Jupiter, Jesse B. . . . . (3B-OHK, 3C-Synthes Eisomed, 4-OHK, . . . . . Poster #102  
5-AO Foundation, 7-Elsevier Thieme,  
8-J of Hand Surg Am, J of Orthop Trauma,  
Techniques in Hand and Upper Extremity Surgery,  
9-AAOS International Committee,  
ASES Resident-Fellow Curriculum Committee)
- Jürgens, C. . . . . (3B-Biomet; Litos) . . . . . Poster #15;  
. . . . . Int'l Poster #29
- Kadokia, Rishin J. . . . . (n) . . . . . Posters #34, 58, 116
- Kadar, Assaf . . . . . (n) . . . . . Poster #4
- Kahler, David M. . . . . (4-Johnson & Johnson, . . . . . Symposium Faculty  
8-Journal of Orthopaedics and Traumatology)
- Kaimrajh, David N. . . . . (6-AOS, Inc., FxDevices, Inc.,  
NuTek Orthopaedics, DePuy) . . . . . Papers #1, 56
- Kain, Michael S. . . . . (n) . . . . . Poster #16
- Kaiser, Scott Patrick . . . . . (n) . . . . . Poster #60
- Kakar, Sanjeev . . . . . (n) . . . . . Posters #101, 103
- Kallan, Michael J. . . . . (n) . . . . . Poster #143
- Kam, Check . . . . . (6-Stryker) . . . . . Paper #18
- Kanakaris, Nikolaos K. . . . . (3B-Stryker - member of the ECAB . . . . . Poster #118  
consulting committee, 5-DePuy, . . . . . Int'l Poster #18  
A Johnson & Johnson Company - Sponsoring an RCT  
to my department and for which I am a co-investigator;  
AMGEN - Sponsoring an RCT to my department  
and for which I am a co-investigator;  
KUROSO - Sponsoring an RCT to my department  
and for which I am a co-investigator;  
Synthes - Sponsoring an RCT to my department  
and for which I am a co-investigator; 5-Synthes)
- Kandemir, Utku . . . . . (5-Biomet; . . . . . Case Presentation Moderator  
Stryker; Synthes)
- Kane, Patrick Martin . . . . . (n) . . . . . Papers #4, 109; Poster #19
- Kang, Barry . . . . . (n) . . . . . Poster #124
- Kang, Daniel Gene . . . . . (n) . . . . . Poster #166, 168, 169
- Kanlic, Enes . . . . . (9-SWOTA, . . . . . Case Presentation Moderator  
South West Orthopaedic Trauma Association)
- Karia, Raj . . . . . (n) . . . . . Posters #40, 79

**Disclosure:**

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## DISCLOSURE LISTING – ALPHABETICAL

Karges, David E. . . . .	(n)	Lab Faculty
Karakoyun, Ozgur . . . . .	(???)	Int'l Poster #23
Karanicolas, P. . . . .	(???)	Int'l Poster #34
Karl, John W. . . . .	(n)	Paper #94
Karunakar, Madhav A. . . . .	(5-Medtronic, 8-Journal of Orthopaedic Trauma, 9-AAOS; . . . . .)	Paper #79, 101; Poster #72 <i>Orthopaedic Trauma Association</i> )
Katarincic, Julia . . . . .	(n)	Paper #109
Kates, Stephen L. . . . .	(2-Medimmune, 5-Synthes, . . . . .)	Symposium Faculty, 7,8-Sage Publications) . . . . . Mini Symposium Moderator
Kauk, Justin R. . . . .	(2,6-Synthes, Smith & Nephew, 6-Stryker) . . . . .	Posters #17, 67
Keeling, John J. . . . .	(n)	Poster #92
Kellam, James F. . . . .	(8-AO Foundation, . . . . .)	Papers #63, 101 9-Canadian Orthopaedic Association; . . . . . Lecturer <i>Orthopaedic Trauma Association, AO Foundation</i> )
Kelly, K. Harvey . . . . .	(3B-Stryker Europe; . . . . .)	Int'l Poster #18 5-DePuy, Stryker, Synthes, Amgen)
Kempton, Laurence B. . . . .	(n)	Paper #101; Poster #72
Ketz, John P. . . . .	(5-Biomimetic) . . . . .	Paper #35, 100; Poster #147
Kfuri, Mauricio . . . . .	(???)	Int'l Posters #3, 4 & 5
Khazzam, Michael . . . . .	(n)	Poster #52
Khoury, Amal . . . . .	(n)	Poster #33; . . . . . Int'l Poster #10
Khurana, Sonya . . . . .	(n)	Poster #40
Kiene, Johannes . . . . .	(n)	Poster #15
Kilcoyne, Kelly . . . . .	(n)	Paper #32
Kingsley, Kendal A. . . . .	(n)	Poster #155
Kinsey, Tracy L. . . . .	(6-Stryker Arthrex, . . . . .)	Poster #180 8-Journal of Arthroplasty)
Kirsch, Thorsten . . . . .	(n)	.Paper #11
Kline, Kelly . . . . .	(n)	Poster #142
Klinger, Craig E. . . . .	(n)	Posters #9, 77
Kloen, P. . . . .	(???)	Int'l Poster #34
Kloub, Martin . . . . .	(???)	Int'l Poster #15
Knobe, Matthias . . . . .	(5-Stryker). . . . .	Poster #153; . . . . . Int'l Posters #13 & 16
Knutsen, Elisa Jeanne . . . . .	(n)	Poster #127
Kobbe, Philipp . . . . .	(n)	Poster #151, 153, 167; . . . . . Int'l Poster #13
Kodumuri, Preetham . . . . .	(n)	Paper #26
Koehler, Daniel M. . . . .	(n)	Poster #149
Koenig, Scott . . . . .	(n)	Paper #45

**Disclosure:**

(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. \*= Not available at time of printing. Refer to pages 620 - 622.

## DISCLOSURE LISTING – ALPHABETICAL

- Koerner, John D. . . . . (n) . . . . . Poster #36
- Konda, Sanjit Reddy . . . . . (n) . . . . . Posters #78, 80, 83
- Koo, Henry . . . . . (???) . . . . . Paper #5
- Koruprolu, Sarath . . . . . (n) . . . . . Paper #4
- Kottmeier, Stephen A. . . . . (n) . . . . . Paper #9;  
. . . . . Mini Symposium Moderator
- Koueiter, Denise . . . . . (n) . . . . . Paper #31
- Kovach, Stephen J. . . . . (n) . . . . . Poster #160;  
. . . . . Mini Symposium Faculty
- Koval, Kenneth J. . . . . (1,2,3B-Biomet, Stryker, 7-Wolters Kluwer . . . . . Paper #85;  
Health - Lippincott Williams & . . . . . Posters #2, 6, 39, 73, 106  
Wilkins, 8-Journal of Orthopaedics and  
Traumatology, 9-AAOS; Orthopaedic Trauma Association)
- Kragh, John F. . . . . (3C-Dr. Kragh is an employee of the US . . . . . Poster #41  
Government and receives institutional support through the  
place where he works, the US Army Institute of Surgical  
Research. He has consulted at no cost with Operative  
Experience, M2, Inc., Tiger Tourniquet, LLC, Tactical  
Medical Solutions, LLC, Combat Medical Systems, Inc.,  
Composite Resources Inc., Delfi Medical Innovations, Inc.,  
North American Rescue Products LLC, H & H  
Associates, Inc., Creative & Effective Technologies, Inc.,  
TEMS Solutions, LLC, Blackhawk Products Group,  
Hemaclear, Tactical Development Group, Compression  
Works, LLC, Tier-One Quality Solutions,  
Kforce Government Solutions, CHI Systems, Teamst,  
Athena GTX, Peliaque, and Entrotech, Inc. ,  
9-Dr Kragh has received honoraria for work for the Food  
and Drug Administration for device consultation.  
He has received honoraria for trustee work for the non-profit  
Musculoskeletal Transplant Foundation.)
- Kraus, Virginia B. . . . . (n) . . . . . Paper #49
- Kreder, Hans J. . . . . (3B-Immediate family consultant for . . . . . Papers #64, 80  
Synthes, 5-Synthes; Biomet; . . . . . Mini Symposium Faculty  
Zimmer, 7-Elsevier Publishing;  
AO North America, 9-Canadian  
Orthopaedic Association, AO Trustee)
- Kregor, Philip J. . . . . (2-Medtronic/Salient, . . . . . Symposium Faculty  
3C-Synthes, AO Technical Commission,  
7-Book Royalties from Thieme)

**Disclosure:**

(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. \* = Not available at time of printing. Refer to pages 620 - 622.

DISCLOSURE LISTING – ALPHABETICAL

Krettek, Christian	(n)	Poster #148; Symposium Faculty; Int'l Poster #33
Krieg, James C.	(1-SAM Medical;Synthes CME, 3B-Synthes; Acumed, LLC, 4-Johnson & Johnson;Domain Surgical; InSyte Medical Technologies, 8-Journal of the American Academy of Orthopaedic Surgeons)	Paper #59, 66; Poster #71
Kruppa, Christiane G.	(n)	Paper #116; Int'l Poster #28
Kubiak, Erik	(3B-Synthes; Tornier; Zimmer; DePuy, A Johnson & Johnson Company; Medtronic, 5-Zimmer, 6-Biomet; Synthes; DePuy; Zimmer, 8-Journal of Orthopaedic Trauma)	Paper #107; Poster #55 Lab Moderator
Kucukkaya, Metin	(???)	Int'l Poster #23
Kudryashov, Valery	(n)	Poster #157
Kuhn, Kevin M.	(n)	Paper #68; Poster #184
Kumar, Rajeev	(n)	Int'l Poster #24
Kupisqewski, Stanley	(n)	Paper #85; Poster #6, 73
Kurien, Tom	(n)	Paper #37; Int'l Poster #17
Kurylo, John	(n)	Paper #41
Kuzyk, Paul Robert	(3B-Avenir Medical Inc., 5-Stryker; Zimmer).	Paper #87; Poster #104
Kwon, John Y.	(n)	Posters #42, 46, 47, 50
Laflamme, George-Yves	(3B-Stryker, 5-Smith & Nephew; Synthes; Stryker)	Papers #46, 81, 89; Posters #94, 98, 99, 132
LaFleur, Brett	(n)	Poster #18
Lamartina, Joey	(n)	Paper #95
Lamont, Lauren E.	(n)	Paper #90; Poster #95
Lane, Joseph M.	(2- Amgen, Eli Lilly; Inc. Novartis, Weber Chilcott, 3B-Amgen, CollPlant, Inc, Bone Therapeutics, SA, BioMimetics, DFine, Graftys, Zimmer, 5-Amgen Co, 9-Orthopaedic Research Society; Musculoskeletal Tumor Society; AAOS; Association of Bone and Joint Surgeons, AOA, ASBMR)	Poster #157 Symposium Faculty
Langfitt, Maxwell K.	(n)	Poster #158
Langford, Joshua	(3B-Stryker, 4-Institute for Better Bone Health, LLC)	Paper #85; Posters #6, 39, 73

**Disclosure:**

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## DISCLOSURE LISTING – ALPHABETICAL

- Lanzi, Joseph ..... (n) ..... Paper #47
- Larson, Timothy ..... (n) ..... Paper #101
- Lasater, Melissa ..... (n) ..... Poster #126
- Latta, Loren L. .... (3C-FxDevices, NuTek Orthopaedics, .... Papers #1, 18, 56  
*Sky Medical, MAKO Surgical, OrthoSensor,  
 Miami Device Solutions, 5-Alphatec Spine;  
 DePuy, A Johnson & Johnson Company;  
 National Institutes of Health (NIAMS & NICHD);  
 Dept. of Defense; Advanced Orthopaedic Solutions;  
 Embrace; Skeletal Dynamics; Toby Orthopaedics;  
 NuTek Orthopaedics; MDPO, LLC; Medtronic Sofamor  
 Danek, Paragon 28, Stryker, 7-Springer; Saunders/Mosby-  
 Elsevier; ASOP, 8-Journal of Orthopaedic Trauma,  
 9-Orthopaedic Trauma Association International Society  
 for Fracture Repair American Society of Orthopaedic  
 Professionals Assoc. for the Rational Treatment of Fractures)*
- Lau, Tak-Wing ..... (n) ..... Symposium Faculty
- Laughlin, Richard T. .... (2-AO North America; Smith & Nephew; ..... Poster #18  
*Synthes; World Arthritis Organization,  
 3B-South Surgery Center, LLC, 3C-Community  
 Tissue Bank - Dayton, OH, 5-Grants: AOFAS;  
 Ohio Third Frontier; OTA; Wright State University  
 Boonshoft School of Medicine, 7-Taylor and Francis  
 Publishing Company, 9-AOFAS - Post Graduate Education  
 Committee; Dayton Area Graduate Medical Education  
 Consortium - Member; Mid-America Orthopaedic  
 Association - Education Committee; South Surgery  
 Center, LLC; Wright State Physicians, Inc. -  
 Board of Directors; Wright State University Boonshoft  
 School of Medicine - Executive Board)*
- Lawendy, Abdel-Rahman ..... (n) ..... Paper #50
- Lawton, Jeffrey F. .... (3B-SBI; Innomed) ..... Mini Symposium Faculty
- Lazaro, Lionel Enrique ..... (n) ..... Papers #90, 119;  
 ..... Posters #9, 14, 38, 48, 56, 77, 84, 95
- Le, Theodore Toan ..... (n) ..... Poster #11
- LeCroy, Charles Michael ..... (2-Johnson & Johnson, 3B-Smith ..... Poster #20  
 & Nephew, 9-AAOS)
- Leduc, Stephane ..... (2-Stryker, 3B-Stryker, 5-Amgen Co; ..... Paper #46  
*DePuy, A Johnson & Johnson Company;  
 Synthes; Stryker; Smith & Nephew)*
- Lee, Jared T. .... (n) ..... Poster #50
- Lee, John ..... (n) ..... Paper #60; Poster #61

**Disclosure:**

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## DISCLOSURE LISTING – ALPHABETICAL

Lefavre, Kelly A.	(5-Synthes; Zimmer)	Poster #63; Mini Symposium Faculty
Lefering, Rolf	(n)	Poster #151
Lehman, Ronald A.	(n)	Poster #166, 168, 169
Leighton, Ross K.	(1-Zimmer, 2-Biomet; 2,3B,5,6-Etex; 2-Smith & Nephew; Stryker; Synthes, Medtronic, 3B-Smith & Nephew; Company; 5-Smith & Nephew; Synthes, Medtronic; 6-Smith & Nephew, Johnson & Johnson, 9-Canadian Orthopaedic Association; Orthopaedic Trauma Association)	Paper #9, 28; Mini Symposium Moderator; OTA Board Stryker, 2,5-DePuy, A Johnson & Johnson
Leslie, Michael P.	(2-Synthes)	Poster #137
Leveille, Lise	(n)	Poster #30
Levin, L. Scott	(1-KLS Martin, L.P.)	Poster #160; Mini Symposium Faculty
Levine, Matthew	(2-arthrex, 4-johnson and johnson)	Paper #48
Lewallen, Laura	(n)	Poster #173
Lewis, Charlotte P.	(n)	Poster #86
Li, Bonnie H.	(???)	Paper #77
Li, Ru	(n)	Paper #15
Liang, Emily	(n)	Poster #134
Lichte, Philipp	(n)	Posters #151, 167; Int'l Poster #13
Liebergall, Meir	(8-Journal of Orthopedic Trauma)	Poster #33; Int'l Poster #10
Lien, John	(n)	Poster #61
Liew, Allan	(n)	Poster #178
Lin, Darius E.	(n)	Poster #47
Lin, Sheldon S.	(3B-Biomimetic; ; Zimmer; Tissuegene, 5-Biomimetic; EBI; Tornier, 8-Foot and Ankle International, 9-American Orthopaedic Foot and Ankle Society)	Poster #191
Lindell, Kenneth	(n)	Paper #47
Lindsay, Adam	(n)	Paper #61
Liporace, Frank A.	(1,2,3B-DePuy, A Johnson & Johnson Company, 2-Synthes; Smith & Nephew; Stryker; Medtronic, 3B-Medtronic; Synthes; Smith & Nephew; Stryker, 3C-AO, 5-Synthes; Smith & Nephew; Acumed)	Posters #36, 39 Lab Faculty
Litrenta, Jody	(n)	Poster #123
Little, Milton Thomas Michael	(n)	Papers #90, 119; Posters #14, 38, 48, 56, 84, 95, 171
Liu, Joseph	(n)	Poster #60

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## DISCLOSURE LISTING – ALPHABETICAL

Loeffler, Bryan J. . . . .	(1-Biomet, 4-MiMedx) . . . . .	Paper #63; Poster #174
Loose, Christopher . . . . .	(3A,4,6-Semprus Biosciences) . . . . .	Paper #22
Lorich, Dean G. . . . .	(n) . . . . .	Papers #90, 119; Posters #9, 14, 38, 48, 56, 77, 84, 95, 171
Lowenberg, David . . . . .	(2,3B-Stryker, 3B-Ellipse Technologies, . . . . .	Poster #1 9-Foundation for Orthopaedic Trauma)
Luitse, Jan S. . . . .	(n) . . . . .	Poster #53
Lundy, Douglas W. . . . .	(3C-Synthes, 4-Livengood Engineering, . . . . .	OTA Board 8-Clinical Orthopaedics and Related Research; Journal of Orthopaedic Trauma; Orthopedics, 9-AAOS; American College of Surgeons; Georgia Orthopaedic Society; Orthopaedic Trauma Association; Orthopaedic Trauma Association)
Ma, Baotong. . . . .	(9-Reviewer of Chinese Orthopaedic . . . . .	Paper #34 Trauma Journal)
Maas, Mario . . . . .	(n) . . . . .	Poster #53; Int'l Poster #34
MacKenzie, Ellen J. . . . .	(8-Injury, . . . . .	Paper #105, 117, 118, 9-National Trauma Institute) . . . . .
MacPherson, Cailan . . . . .	(n) . . . . .	Poster #150
Madsen, Jan Erik . . . . .	(n) . . . . .	Paper #62
Maiale, Michael . . . . .	(n) . . . . .	Poster #25
Makridis, Kostas . . . . .	(n) . . . . .	Poster #118
Malekzadeh, A. Stephen . . . . .	(n) . . . . .	Paper #48
Mangiapani, Daniel S. . . . .	(n) . . . . .	Paper #49
Mangupli, Martin Marcelo . . . . .	(n) . . . . .	Poster #163; Int'l Poster #32
Manson, Theodore T. . . . .	(n) . . . . .	Papers #57, 67; Posters #76, 130; Moderator
Maratt, Joseph . . . . .	(3A,4-Sanofi-Aventis; Merck; . . . . .	Poster #61 Momenta Pharma)
Marcantonio, Andrew J. . . . .	(9-New England Orthopaedic Society - . . . . .	Poster #16 Membership Chairman)
Marchie, Alfonse . . . . .	(???) . . . . .	Poster #90
Marchie, Anthony . . . . .	(n) . . . . .	Poster #90
Marcucio, Ralph . . . . .	(n) . . . . .	Paper #10
Marcus, Matthew S. . . . .	(n) . . . . .	Poster #39
Marion, Travis E. . . . .	(n) . . . . .	Poster #178
Markel, David . . . . .	(n) . . . . .	Papers #20, 23
Marks, Tyler . . . . .	(n) . . . . .	Paper #32

**Disclosure:**

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DISCLOSURE LISTING – ALPHABETICAL

Marmor, Meir	..... (n) .....	Paper #3; Poster #114; Symposium Faculty
Marolen, Khensani N.	..... (n) .....	Posters #43, 189
Marriott, Tricia	..... (n) .....	Mini Symposium Faculty
Marsh, David	..... (???) .....	Poster #27
Marsh, J. Lawrence	..... (n) .....	Paper #17
Martens, Patrick	..... (n) .....	Poster #11
Martusiewicz, Alex	..... (n) .....	Paper #60
Mascarenhas, Leonardo	..... (???) .....	Int'l Poster #4
Matache, Bogdan A.	..... (n) .....	Poster #133
Matityahu, Amir M.	..... (2-Synthes; DePuy, A Johnson & Johnson Company, 3B-DePuy, 4-Anthem Orthopaedics, LLC Anthem Orthopaedics VAN, LLC, .. 5-Stryker and Synthes)	Paper #3; Poster #114 Moderator Symposium Moderator
Matre, Kjell	..... (5-Smith & Nephew) .....	Paper #27; Symposium Faculty
Matuszewski, Paul Edward	..... (n) .....	Poster #131
Matzko, Michelle E.	..... (n) .....	Paper #30
McAlister, Jeffrey Eugene	..... (n) .....	Paper #48
McAndrew, Christopher M.	..... (2-Synthes) .....	Paper #73; Posters #22, 164, 165
McCann, Fannie	..... (n) .....	Poster #98
McClincy, Michael P.	..... (n) .....	Poster #190
McClure, Jake	..... (n) .....	Poster #189
McConnell, Alison J.	..... (???) .....	Paper #5
McDonald, Matthew R.	..... (n) .....	Poster #43
McGough, Richard	..... (n) .....	Poster #8
McIntosh, Amy	..... (n) .....	Poster #173
McKee, Michael D.	..... (1-Stryker, 2,3B-Synthes; 2,3B,5-Zimmer, 5-Wright Medical Technology, Inc.; 7-Wolters Kluwer Health - Lippincott Williams & Wilkins, .....	Papers #5, 87, 91; Poster #29; Moderator; Symposium Faculty; Mini Symposium Moderator; Mini Symposium Faculty; Case Presentation Faculty; Lab Faculty; OTA Committee
McKinley, Todd O.	..... (9-Orthopaedic Trauma Association) .....	Poster #133

**Disclosure:**

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## DISCLOSURE LISTING – ALPHABETICAL

- McLaren, Alexander C. . . . . (4-Sonoran Biosciences, 5-OREF Herb Loius. . . . Paper #24  
Fund; AO North America; SWOTA (South West  
Orthopaedic Trauma Assoc); Banner Health;  
Arizona Biomedical Reserarch Commission; Astellas;  
6-Synthes; Artificial Limb Specialists; Banner Health;  
Arthrex, Inc; Cactis Foundation; Research Recovery  
Institute; TriMed Inc; Biomet Inc; Stryker;  
Smith and Nephew; Orthopaedic Trauma Association)
- McLemore, Ryan . . . . . (n) . . . . . Paper #24
- McMichael, Jessica Cole . . . . . (n) . . . . . Poster #120
- McQueen, Margaret M. . . . . (8- Wolters Kluwer Health - . . . . . Papers #44, 74, 84, 92;  
Lippincott Williams & Wilkins) . . . . . Posters #57, 97, 107;  
. . . . . Int'l Posters #26 & 30
- McQuiston, Christina . . . . . (n) . . . . . Poster #20
- McWilliams, A. B. . . . . (n) . . . . . Poster #118
- Medhi, Bikash . . . . . (n) . . . . . Poster #192
- Meghidido, Gabby . . . . . (n) . . . . . Poster #4
- Mehlman, Charles T. . . . . (3C-Stryker, 7-Oakstone Medical Publishing, . . . Paper #108;  
8-Journal of Bone and Joint Surgery - American; Poster #177;  
Journal of Orthopaedics and . . Mini Symposium Moderator  
Traumatology; Journal of Pediatric  
Orthopedics; Saunders/Mosby-  
Elsevier; Spine; Wolters Kluwer Health -  
Lippincott Williams & Wilkins, 9-AAOS;  
Pediatric Orthopaedic Society of North America;  
Scoliosis Research Society)
- Mehta, Samir . . . . . (2-Zimmer; AO North America, . Posters #25, 117, 143, 160  
2,3B,5-Smith & Nephew; . . . Mini Symposium Moderator,  
3B-Synthes, 5-Amgen Co; . . . Case Presentation Faculty  
Medtronic, 7-Wolters Kluwer Health  
- Lippincott Williams & Wilkins,  
8-Current Opinion in Orthopaedics,  
9-Pennsylvania Orthopaedic Society)
- Meinberg, Eric . . . . . (2,3B-Synthes; Medtronic, . . . . . Symposium Faculty  
3B-Amgen Co, 9-Northern California Chapter,  
Western Orthopaedic Association)
- Melvin, James S., III, . . . . . (4-Cadence) . . . . . Paper #32
- Merlin, Gabriel . . . . . (n) . . . . . Paper #45
- Merk, Bradley R. . . . . (2,5-Synthes, 2,3B,5-Stryker, . . . . . Lab Faculty  
8-American Journal of Orthopedics)
- Merriman, David J. . . . . (n) . . . . . Poster #22
- Mesbah, Abdul Ghani. . . . . (???) . . . . . Int'l Poster #9

**Disclosure:**

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DISCLOSURE LISTING – ALPHABETICAL

METALS	(n)	Poster #93
METRC	(n)	Posters #119, 121
Meyer, Darlene	(n)	OTA Staff
Micansky, Fabian	(n)	Poster #151
Miclau, Theodore, III	(3B-Amgen Co; 4-Johnson & Johnson; Merck; Pfizer; 5-Stryker; Synthes, 9-AO; Orthopaedic Research Society; Orthopaedic Trauma Association; Osteosynthesis and Trauma Care Foundation)	Paper #10; Moderator Symposium Moderator OTA Committee
Miguel Pishnamaz	(n)	Poster #167
Miller, Anna N.	(3B-Synthes, 6-Smith & Nephew)	Poster #158
Milne, Edward	(4-Stryker stock, 6-FxDevices LLC, AOS Inc., Toby Orthopedics LLC, Nutek Orthopedics LLC)	Papers #1, 56
Mir, Hassan R.	(8-OTA Newsletter Editor; Journal of Orthopaedic Trauma Consultant Editor; Journal of the American Academy of Orthopaedic Surgeons Consultant Reviewer; Journal of Bone and Joint Surgery Consultant Reviewer, 9-AAOS Diversity Advisory Board Member; Orthopaedic Trauma Association Public Relations Committee)	Posters #34, 58, 116, 128, 179, 185, 187 Mini Symposium Moderator
Miranda, Michael A.	(2-Synthes, 4-Johnson & Johnson; Pfizer)	Mini Symposium Faculty
Mirick, Gudrun	(n)	Paper #3
Mirza, Amer J.	(2,3B,3C-Acumed, LLC, 3C-Seattle Information Systems)	Poster #31; Case Presentation Faculty Lab Faculty
Misfeldt, Michael	(n)	Paper #16
Mitchell, Sarah E.	(n)	Paper #92
Moed, Berton R.	(1-DePuy, A Johnson & Johnson Company, 7,8-Clinical Orthopaedics and Related Research, 8-Journal of Orthopaedic Trauma, Injury)	Paper #55; Posters #70, 74, 120
Moffatt, D.	(???)	Int'l Poster #27
Moghadamian, Eric S.	(2-Synthes - Synthes Operating Room Personnel Course; Per Diem for faculty)	Poster #112
Molina, Domingo, IV	(n)	Posters #45, 49
Molyneux, Sam G.	(n)	Paper #92; Poster #28
Montijo, Harvey	(n)	Papers #79, 101

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## DISCLOSURE LISTING – ALPHABETICAL

Monzon, Daniel Godoy	(n)	Posters #7,159
Moor, Molly A.	(n)	Paper #113
Moore, Sharon	(n)	OTA Staff
Moore, Timothy A.	(n)	Papers #8, 43, 102; Posters #140, 156
Moossy, John	(n)	Posters #62, 65
Moran, Christopher G.	(2-Smith & Nephew, 8-International Editorial Board, Injury, 9-British Orthopaedic Association)	Symposium Moderator, Mini Symposium Faculty; Int'l Poster #17
Moran, Steven L.	(1,2-Acension, 8-Journal of Hand Surgery - American)	Posters #101, 108
Morgan, Jordan Houston	(n)	Paper #72
Morgan, Steven J.	(2-Smith & Nephew, 4-Johnson & Johnson; Emerge Medical, 8-Journal of Orthopaedic Trauma, 9-Orthopaedic Trauma Association, Western Orthopaedic Trauma Association)	Lab Faculty
Morrey, Bernard F.	(1,3B-Zimmer, SBI)	Poster #89
Morris, Brent J.	(n)	Poster #126
Morris, Claire	(???)	Paper #37
Morrison, Martin J. III	(n)	Paper #110
Morscher, Melanie A.	(4-Bristol-Myers Squibb; Merck; Pfizer (very limited number of shares))	Paper #112
Morshed, Golam	(n)	Paper #5
Morshed, Saam	(5-Stryker; Synthes)	Poster #60; Moderator, Symposium Moderator, Symposium Faculty
Mosheiff, Rami	(n)	Poster #33
Mubarak, Scott J.	(4-Rhino Pediatric Orthopedic Designs, 7-Springer)	Paper #113
Mudd, Christopher D.	(n)	Poster #70
Mulawka, Brett	(n)	Poster #96
Mulder, Michelle B.	(n)	Paper #116
Mullis, Brian H.	(2-Medtronic; Smith & Nephew, 2,5-Synthes, 5-Amgen Co, 8-Journal of Orthopaedic Trauma, 9-Orthopaedic Trauma Association)	Paper #9; Poster #68
Munro, Mark	(n)	Paper #85; Posters #6, 73
Murray, Clinton	(n)	Paper #99; Poster #186
Murtha, Yvonne M.	(n)	Papers #16, 104; Poster #52
Mutch, Jennifer	(n)	Paper #89; Posters #94, 99

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## DISCLOSURE LISTING – ALPHABETICAL

Mutty, Christopher E.	(n)	Paper #98; Poster #154
Mutyaba, Patricia L.	(n)	Paper #14
Nally, Chuck	(n)	Paper #9
Napierala, Matthew	(n)	Paper #99; Poster #186
Nascone, Jason W.	(1,3B-Synthes, 8-Journal of Orthopaedic Trauma)	Poster #130 Mini Symposium Faculty
Naslund, John	(n)	Poster #82
Nault, Marie-lyne	(2-Smith & Nephew)	Paper #46
Nauth, Aaron	(5-Synthes, Stryker)	Paper #15; Poster #29
Navarro, Ronald A.	(5-Acumed, LLC; Arthrex, Inc;	Paper #77 9-AAOS; American Board of Orthopaedic Surgery, Inc.; American Orthopaedic Society for Sports Medicine)
Nelson, Kenneth Joseph	(n)	Paper #63, 117, 118
Nesti, Leon J.	(9-Orthopaedic Research Society;	Symposium Faculty American Society for Surgery of the Hand)
Niece, Krista	(n)	Paper #21
Nisenbaum, Rosane	(???)	Paper #5
Noel, Scott	(3A,6-Bionova Medical Inc, 4-Bionova Medical Inc, SixFix Inc)	Paper #54
Nork, Sean	(2-Stryker; 2,3B,5-AONA, Synthes; 3B,5-Amgen, 5-OTA)	Paper #66
North, Kylee	(n)	Poster #55
Norton, Robert P.	(4-Invivo Therapeutics; Internal Fixation Systems)	Paper #1, 56
O’Boynick, Christopher	(n)	Poster #74
O’Brien, Peter J.	(5-Synthes, Stryker)	Posters #30, 63
O’Connor, Daniel P.	(3C-Nimbic, Inc., 7-Slack, Inc. (book author royalties))	Poster #181
O’Mara, Timothy J.	(4-Orthopaedic Implant Company, 8-Journal of Orthopaedic Trauma)	Paper #106; Posters #17, 67
O’Toole, Robert V.	(3B,5-Synthes, 5-Stryker; 9-Orthopaedic Trauma Assoc.)	Papers #51, 57, 75; Posters #76, 127, 130, 131; Moderator; OTA Committee
Obakponovwe, O.	(3B-Stryker Europe; 5-DePuy, Stryker, Synthes, Amgen)	Int’l Poster #18

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## DISCLOSURE LISTING – ALPHABETICAL

- Obremskey, William T. . . . . (3B-Biomimetic, . . . . . Paper #114;  
9-Orthopaedic Trauma Association; . Posters #109, 113, 122,  
AAOS) . . . . . 124, 128, 129, 145; EBM Poster;  
. . . . . Mini Symposium Moderator,  
. . . . . Mini Symposium Faculty,  
. . . . . Case Presentation Moderator
- Ochs, Björn Gunnar . . . . . (n) . . . . . Int'l Poster #14
- Oikonomidis, Stavros . . . . . (n) . . . . . Poster #167
- Oliphant, Bryant Will . . . . . (n) . . . . . Poster #69, 88
- Oliver, Noah . . . . . (n) . . . . . Paper #48
- Oliver, Shelley M. . . . . (n) . . . . . Poster #172
- Ollivere, Benjamin. . . . . (n) . . . . . Papers #7, 26, 37
- Olson, Patrick R. . . . . (n) . . . . . Paper #94
- Olson, Steven A. . . . . (3B-Bioventus, 5-Smith & Nephew; . . . . . Paper #49  
Synthes, 6-Synthes) . . . . . EBM Poster; Moderator,  
. . . . . Symposium Moderator;  
. . . . . Symposium Faculty,  
. . . . . Mini Symposium Faculty
- Orchowski, Joseph . . . . . (n) . . . . . Paper #47
- Orem, Alexander O. . . . . (n) . . . . . Poster #82
- Ortega, Gilbert R. . . . . (2-Smith & Nephew, 3B-Smith & Nephew). . . . . Paper #24
- Osgood, Greg . . . . . (3B,5-Synthes; Stryker, . . . . . Lab Faculty  
5-Smith & Nephew, 8-Journal of Orthopaedics  
and Traumatology, 9-Orthopaedic Trauma  
Association; Foundation for Orthopaedic Trauma)
- Ostrum, Robert F. . . . . (3B-Smith & Nephew, Synthes, . . . . . Poster #32;  
5-AONA, Synthes, . . . . . Case Presentation Faculty  
8-Journal of Orthopaedic Trauma- . . . . . Moderator  
American, Journal of Orthopaedics)
- Otlans, Peter . . . . . (n) . . . . . Poster #123
- Ouellette, Elizabeth Anne . . . . . (3B-Stryker, Synthes, 9-AAOS, . . . . . Paper #18  
Communications Cabinet Liason to Women's Health  
Issues Advisory Board; American Association for  
Hand Surgery; ASSH, Co-Chairman, Business of  
Hand Surgery Committee, 2010-2013)
- Owens, Johnny . . . . . (n) . . . . . Poster #44
- Ozer, Kagan . . . . . (n) . . . . . Mini Symposium Moderator
- Paech, Andreas . . . . . (n) . . . . . Poster #15
- Paller, David . . . . . (n) . . . . . Paper #4; Poster #19

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## DISCLOSURE LISTING – ALPHABETICAL

Panchbhavi, Vinod Kumar . . . . .	(8-Foot and Ankle International, . . . . . Posters #45, 49 Techniques in Foot & Ankle Surgery, Orthopedia.com, 9-American Orthopaedic Foot and Ankle Society)
Papandrea, Rick . . . . .	(2,3B-Acumed, LLC; . . . . . Mini Symposium Faculty Exactech, Inc)
Pape, Hans-Christoph . . . . .	(3B-Zimmer, 5-Stryker, . . . . . Posters #62, 65, 151, 7-Journal of Orthopaedic Research; . . . . . 153, 155, 167 Wolters Kluwer Health -Lippincott . . . . . Lab Faculty Williams & Wilkins; Springer, . . . . . Int'l Posters #13 & 16 8-J Orthop Trauma Injury, Open access Emergency Medicine)
Papp, Steven . . . . .	(n) . . . . . Poster #178
Parasu, Naveen . . . . .	(n) . . . . . Poster #23
Pardee, Nadine C. . . . .	(n) . . . . . Paper #90; Poster #9, 14, 38, 56, 77, 84, 95
Park, Ji Hae . . . . .	(n) . . . . . Paper #71
Park, Si-Hyeong . . . . .	(n) . . . . . Paper #70
Partridge, Maggie . . . . .	(???) . . . . . Poster #27
Paryavi, Ebrahim . . . . .	(n) . . . . . Paper #75; Posters #127, 138
Patel, Alpesh . . . . .	(1,3B-Amedica, 3B-Biomet; GE Healthcare; . . . . . Poster #169 Stryker; Trinity Orthopaedics, 4-Amedica; Cytonics; Nocimed; Trinity Orthopaedics, 7-Springer, 8-Surgical Neurology International; Wolters Kluwer Health - Lippincott Williams & Wilkins, 9-AAOS; American College of Surgeons; American Orthopaedic Association; AO Spine North America; Cervical Spine Research Society; Lumbar Spine Research Society; North American Spine Society)
Patel, Harshita . . . . .	(n) . . . . . Paper #5
Patel, Karan A. . . . .	(n) . . . . . Poster #49
Patel, Neeraj M. . . . .	(n) . . . . . Poster #36
Patel, Shaun . . . . .	(n) . . . . . Paper #58
Paterson, Michael . . . . .	(n) . . . . . Paper #80
Patzkowski, Jeanne C. . . . .	(n) . . . . . Poster #44
Payton, Alivia . . . . .	(n) . . . . . OTA Staff
Pearson, R. G. . . . .	(n) . . . . . Int'l Poster #17
Peck, Valerie . . . . .	(n) . . . . . Paper #71
Pelet, Stéphane. . . . .	(5-Arthrex Inc, Amgen, Astra Zeneca, 9-Président Comité de DPC AOQ) . . . . . Paper #91
Penn-Barwell, Jowan G. . . . .	(n) . . . . . Papers #52, 53
Pennock, Andrew . . . . .	(n) . . . . . Paper #113
Peterson, Blake E. . . . .	(n) . . . . . Paper #16

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## DISCLOSURE LISTING – ALPHABETICAL

Petit, Yvan	(n)	Paper #81; Poster #98
Petrisor, Brad A.	(2,3B,5-Stryker; 5,6-Synthes)	Poster #23; Symposium Faculty
Petteys, Tim	(3A-Smith & Nephew)	Paper #6
Pfeifer, Roman	(n)	Posters #151, 153; Int'l Poster #13
Pfeiffer, Ferris M.	(n)	Poster #51
Phisitkul, Phinit	(n)	Paper #17
Pinzur, Michael	(2-Biomimetic; SBI; Smith & Nephew;	Poster #191 Wright Medical Technology, Inc.; KCI, 3B-SBI; Biomimetic; Wright Medical Technology, Inc.; KCI, 5-Biomimetic, 8-Foot and Ankle International; Orthopedics Today, 9-American Orthopaedic Foot and Ankle Society; AAOS)
Pishnamaz, Miguel	(n)	Poster #167
Pizzutillo, Peter	(n)	Poster #176
Place, Alexandre	(n)	Poster #132
Plecko, Michael	(???)	Int'l Poster #15
Podeszwa, David A.	(9-Pediatric Orthopaedic Society of North America)	Poster #175 Case Presentation Moderator
Poeze, Martijn	(n)	Paper #38
Poka, Attila	(2-Stryker, 3B-Biomet Trauma)	Poster #152
Pollak, Andrew N.	(1-Extraortho; Zimmer,	Paper #34; 3B,5-Smith & Nephew, 7-AAOS, 8-SLACK Incorporated, 9-National Trauma Institute; Orthopaedic Trauma Association)
Ponzer, Sari	(n)	Paper #29
Poolman, Rudolf W.	(???)	Int'l Poster #34
Porter, Jake	(n)	Poster #129
Potter, Benjamin K.	(5-Nanotherapeutics)	Posters #41, 68, 92, 180
Powell, Mallory	(n)	Posters #109, 129, 145
Prayson, Michael J.	(2-AO Faculty, 2,3B,5-Smith & Nephew, . . .	Posters #1, 18 5-Synthes, 8-Journal of Orthopaedic Trauma; Journal of Trauma; Acta Orthopaedica, 9-Wright State Physicians, Inc; Orthopaedic Trauma Association)
Prescher, Andreas	(5-Stryker)	Int'l Posters #13 & 16
Principe, Michael J.	(n)	Poster #152

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## DISCLOSURE LISTING – ALPHABETICAL

Probe, Robert A. ....	(2-Synthes, 2,3B-Stryker, 8-Journal of Bone and Joint Surgery - American; Journal of the American Academy of Orthopaedic Surgeons, ..... OTA Board Journal of Orthopaedic Trauma Journal of Trauma, 9-Orthopaedic Trauma Association, Scott & White HealthCare, Scott & White Memorial Hospital)	Paper #9; Poster #26 Lab Faculty
Prommersberger, Karl-Josef ...	(n) .....	Poster #102
Pugh, Kevin J. ....	(2,3C-Synthes, 2,3B-Medtronic; . Mini Symposium Faculty Smith & Nephew, 3C-AO North America, 5-Medtronic, 8-Journal of Orthopaedic Trauma, 9-AAOS)	
Quinnan, Stephen M. ....	(2,3B-Smith & Nephew, ..... Mini Symposium Faculty 4-Internal Fixation Systems)	
Quirno, Martin .....	(n) .....	Paper #11
Qvick, Lars Mikael .....	(n) .....	Paper #98; Poster #154
Rabalais, Denise .....	(n) .....	Poster #126
Raglan, M. ....	(n) .....	Int'l Poster #17
Raj, Saloni .....	(???) .....	Int'l Poster #12
Rand, Ben .....	(n) .....	Papers #53, 54
Randell, Timothy .....	(n) .....	Poster #26
Reddix, Robert N. Jr., .....	(2-Orthofix, Inc., ..... 2,3B-Integra Life Sciences)	Posters #5, 13
Reid, J. Spence. ....	(2,3B-Smith & Nephew, 3B-Synthes, ..... 8-Journal of Orthopaedics and Traumatology)	Lab Faculty
Reilly, Mark Cameron .....	(2-Synthes; Smith & Nephew; Stryker) .....	Poster #36 Lab Moderator
Reilly, Patrick M. ....	(n) .....	Poster #143
Reimers, Nils .....	(3A-Stryker) .....	Poster #24; Int'l Poster #29
Ren, Weiping .....	(n) .....	Papers #20, 23
Reynolds, Lisa .....	(n) .....	Paper #76
Rhee, Peter .....	(n) .....	Poster #101
Rhemrev, Steven .....	(n) .....	Paper #93
Rhodewalt, Stefan .....	(n) .....	Paper #107
Rhorer, Anthony S. ....	(2,3B,5-Smith & Nephew, 6-Synthes) .....	Lab Faculty
Riblet, Natalie .....	(n) .....	Poster #82

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## DISCLOSURE LISTING – ALPHABETICAL

- Ricci, William M. . . . . (1,3B,5-Smith & Nephew; . . . . . Paper #73;  
1,3B-Wright Medical Technology, Inc., Posters #22, 164, 165  
3B-Biomet; Stryker, . . . . . Mini Symposium Faculty  
7,8-Wolters Kluwer Health -  
Lippincott Williams & Wilkins, 8-Journal of  
Orthopaedic Trauma, 9-Orthopaedic Trauma Association,  
American Orthopaedic Association). . . . .
- Riccio, Anthony I. . . . . (2-Synthes) . . . . . Case Presentation Faculty
- Richard S Yoon, MD. . . . . (n) . . . . . Poster #36
- Richards, Justin E. . . . . (n) . . . . . Posters #126, 149
- Richards, R. Geoff . . . . . (8-Editor-In-Chief eCM . . . . . Symposium Moderator,  
True Open Access Journal, . . . . . Symposium Faculty,  
published by AO Research Institute Davos . . . . . Moderator  
Preclinical research in the musculoskeletal field (IF 9.65)  
<http://www.ecmjjournal.org>, 9-Executive Committee  
member EORS (European Orthopaedic Research Society  
<http://www.eors.eu>); Orthopaedic Research Society  
(Infection and Inflammation Topic - Chair))
- Riehl, John . . . . . (n) . . . . . Paper #85; Posters #6, 73
- Rieser, G. Ryan . . . . . (n) . . . . . Poster #18
- Rikli, Daniel R. . . . . (n) . . . . . Poster #108
- Riley, Patrick M. . . . . (n) . . . . . Paper #112
- Riley, Patrick M. Jr, . . . . . (n) . . . . . Paper #112
- Rimmke, Nathan . . . . . (n) . . . . . Poster #88
- Ring, David C. . . . . (1,3B-Wright Medical Technology, Inc., . . . . . Paper #93  
3B-Biomet; Skeletal Dynamics, 4-Illuminos,  
8-Journal of Hand Surgery - American; Journal of  
Orthopaedic Trauma, 9-American Shoulder and  
Elbow Surgeons; American Society for Surgery of the Hand)
- Ringler, James R. . . . . (n) . . . . . Poster #172
- Ristevski, Bill . . . . . (n) . . . . . Poster #29
- Rivera, Jessica . . . . . (n) . . . . . Poster #186
- Rives, Terry . . . . . (n) . . . . . Poster #5
- Robinson, Tiana L. . . . . (n) . . . . . Poster #155
- Rockwood, Todd . . . . . (n) . . . . . Poster #141
- Rodriguez-Elizalde, Sebastian. . . . . (n) . . . . . Paper #64
- Rodriguez, Edward K. . . . . (1-Zimmer, 4-MXO Orthopedics, 5-Synthes) . . . . . Paper #72
- Roehrich, Joshua . . . . . (n) . . . . . Paper #108
- Røise, Olav . . . . . (n) . . . . . Paper #62
- Rollins, Katie Elisabeth . . . . . (n) . . . . . Paper #7
- Roncolato, Diego . . . . . (n) . . . . . Posters #7, 159
- Roscoe, Martin . . . . . (???) . . . . . Poster #90

**Disclosure:**

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## DISCLOSURE LISTING – ALPHABETICAL

Rosenberg, Zehava S. ....	(n) .....	Paper #71
Rosenwasser, Melvin P. ....	(1-Biomet, 3B-Stryker, .....	Paper #94
	8-American Journal of Orthopedics,	
	9-Osteosynthesis and Trauma Care Foundation)	
Rossiter, Nigel .....	(9-ISIS - ISIS Indemnity Scheme).....	Poster #182
Roster, Brent .....	(n) .....	Poster #31
Roth, Howard .....	(???) .....	Poster #100
Rothstock, Stephan .....	(???) .....	Int'l Poster #15
Rouleau, Dominique .....	(2,5-Smith & Nephew, 5-DePuy, .....	Papers #81, 89;
	A Johnson & Johnson Company; ...	Posters #94, 98, 99, 132
	KCI; Stryker; Synthes; Zimmer)	
Roush, Timothy .....	(n) .....	Poster #170
Routt, Milton L., Jr. ....	(n) .....	Papers #59, 66; Posters #59, 60, 71
Ruffolo, Michael .....	(n) .....	Paper #79
Russell, Gregory B. ....	(n) .....	Poster #158
Russell, Thomas A. ....	(1-Smith & Nephew; Knee Creations, ..	Symposium Faculty,
	3A,4-Innovision, Inc., .....	Mini Symposium Faculty
	3C,4-ETEX, 7-Wolters Kluwer Health - Lippincott	
	Williams & Wilkins)	
Russo, Franco .....	(n) .....	Paper #113
Ruth, John T. ....	(9-Orthopaedic Trauma Association) .....	Poster #81;
	.....	Moderator;
	.....	OTA Committee
Sabal, Luigi A. ....	(n) .....	Lab Faculty
Saccone, Michel .....	(n) .....	Poster #104
Safran, Ori .....	(n) .....	Int'l Poster #10
Sagi, H. Claude .....	(1,2,3B,5-Stryker, 2-AO/Synthes, .....	Paper #9, 65, 78, 115;
	2,3B,5-Smith & Nephew, .....	Posters #10, 162;
	3B,5-Synthes; .....	EBM Poster; Moderator,
	8-Journal of Orthopaedic Trauma, ...	Symposium Faculty,
	9-AAOS; .....	Mini Symposium Faculty
	9-AAOS; Orthopaedic Trauma Association;	
	Foundation for Orthopaedic Trauma)	
Saltzman, Charles L. ....	(n) .....	Paper #107
Sanchez-Sotelo, Joaquin .....	(1-Stryker, 3B-Stryker) .....	Poster #89
Sanders, David W. ....	(3B,5-Smith & Nephew, 5-Synthes, .....	Paper #50
	8-Journal of Orthopaedics and Traumatology) ...	Moderator

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## DISCLOSURE LISTING – ALPHABETICAL

- Sanders, Roy . . . . . (1-CONMED Linvatec; DePuy, . . . . . Papers #42, 78, 115; A Johnson & Johnson Company; Stryker, . . . . . Poster #162 1,2,3B,5-Smith & Nephew; . . . . . Mini Symposium Faculty 2,3B,5-Medtronic, 5-Health and Human Services; National Institutes of Health (NIAMS & NICHD); Stryker, METRC (DOD), 7-Journal of Orthopaedic Trauma, 8-Journal of Orthopaedic Trauma)
- Sandman, Emilie . . . . . (n) . . . . . Paper #81; Poster #98
- Saper, David . . . . . (n) . . . . . Poster #123
- Sasaki, Sebastian . . . . . (n) . . . . . Posters #7, 159
- Sassoon, Adam . . . . . (n) . . . . . Poster #188
- Sathiyakumar, Vasanth . . . . . (n) . . . . . Poster #129
- Sawardeker, Prasad . . . . . (6-Stryker). . . . . Paper #18
- Scannell, Brian P. . . . . (n) . . . . . Paper #63; Poster #170
- Scheidler, William David . . . . . (n) . . . . . Paper #58
- Schemitsch, Emil H. . . . . (1,3B,6-Stryker, 3B-Amgen Co; Smith & Nephew; Wright Medical . . . . . Papers #5, 15, 78; & Nephew; Kuros, . . . . . Moderator, Technology, Inc.; Kuros, . . . . . Moderator, 5-Smith & Nephew, . . . . . Symposium Moderator, 6-Canadian Institutes of Health . . . . . Symposium Faculty, Research (CIHR); OMEGA; . . . . . Mini Symposium Faculty Smith & Nephew; Zimmer; Synthes, 7-Saunders/Mosby-Elsevier, 8-Journal of Orthopaedic Trauma, 9-Orthopaedic Trauma Association; Canadian Orthopaedic Association; Osteosynthesis and Trauma Care Foundation)
- Schemitsch, Laura . . . . . (n) . . . . . Paper #87
- Schenker, Mara . . . . . (n) . . . . . Poster #117
- Schep, Niels W. . . . . (n) . . . . . Poster #53
- Schildhauer, T. A. . . . . (n) . . . . . Int'l Poster #28
- Schmidt, Andrew H. . . . . (1,3B-Smith & Nephew, 2,3B-Medtronic, . . . . . Paper #9; 3B-DGIMed Orthopedics; AGA, . . . . . Poster #87, 108 3C-Conventus Orthopaedics, . . . . . Case Presentation Faculty; 3C,4,5-Twin Star Medical, . . . . . OTA Board 4-Anthem Orthopedics; Conventus Orthopaedics; International Spine and Orthopedic Institute, 7-Thieme, Inc., 8-Journal of Orthopaedic Trauma; Journal of Knee Surgery, 9-Orthopaedic Trauma Association)
- Schmidt, Jörg . . . . . (???) . . . . . Poster #108
- Schiama, Damiano . . . . . (???) . . . . . Int'l Poster #15
- Scholtes, V.A.B. . . . . (???) . . . . . Int'l Poster #34

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## DISCLOSURE LISTING – ALPHABETICAL

Schottel, Patrick C. . . . .	(n) . . . . .	Papers #90, 119; Posters #14, 84, 95
Schroeder, Manuel . . . . .	(5-Stryker). . . . .	Poster #24
Schulman, Jeff E. . . . .	(2,5-Synthes). . . . .	Paper #48
Schultz, Karen . . . . .	(3A,4-Semprus Biosciences). . . . .	Paper #22
Schulz, Arndt P. . . . .	(5-Arthrex, Inc; DePuy, . . . . .	Posters #15, 24; A Johnson & Johnson Company;. . . . . Int'l Poster #29 GlaxoSmithKline; Link Orthopaedics; Stryker; LITOS, Baxter, 8-Springer, 9-European Federation of National Associations of Orthopedics and Traumatology; Internet Society of Orthopaedic Surgery and Trauma, DGU)
Schultz, Robert S. . . . .	(n) . . . . .	Lab Faculty
Schwartzbach, Cary C. . . . .	(n) . . . . .	Paper #48
Schwarz, Edward . . . . .	(2,3B-MedImmune; 4-LAGeT; . . . . .	Mini Symposium Faculty 5-Codevax, MedImmune, LAGeT; 9-Orthopaedic Research Society)
Sciadini, Marcus F. . . . .	(2-Stryker, 3B-Stryker, 4-Stryker) . . . . .	Poster #130
Scott, Aaron T. . . . .	(8-Editorial board for The Journal of . . . . .	Poster #158 Arthroscopy and Related Surgery and for The Journal of Surgical Orthopaedic Advances)
Sculco, Peter K. . . . .	(n) . . . . .	Posters #9, 38, 48, 56, 77
Selby, Jeffrey B. . . . .	(n) . . . . .	Poster #112
Selhi, Harpal Singh . . . . .	(???) . . . . .	Int'l Poster #2
Seligson, David . . . . .	(3B-Stryker, 9-Kuentscher Society) . . . . .	Lab Faculty
Sellei, Richard M. . . . .	(n) . . . . .	Posters #151, 153, 167; Int'l Poster #13
Sems, Stephen A. . . . .	(1-DePuy, A Johnson & Johnson Company) . . . . .	Paper #19; Posters #173, 188
Sen, Milan K. . . . .	(n) . . . . .	Poster #181; Case Presentation Faculty, Lab Faculty
Serrano-Riera, Rafael . . . . .	(n) . . . . .	Papers #65, 78; Poster #10
Sethi, Anil . . . . .	(n) . . . . .	Poster #88
Sethi, Manish K. . . . .	(n) . . . . .	Posters #43, 109, 124, 126, 128, 129, 145, 189; Mini Symposium Faculty
Seybold, D. . . . .	(n) . . . . .	Int'l Poster #28
Seymour, Rachel . . . . .	(n) . . . . .	Paper #79
Shahab, Faseeh . . . . .	(n) . . . . .	Lab Faculty
Shahab-uddin, Prof . . . . .	(n) . . . . .	Lab Faculty
Shar, Adam . . . . .	(n) . . . . .	Poster #26

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## DISCLOSURE LISTING – ALPHABETICAL

Shazar, Nachshon	(n)	Int'l Poster #20
Shawen, Scott	(9-American Orthopaedic Foot and Ankle Society Humanitarian Aid Committee; American Orthopaedic Foot and Ankle Society)	Poster #41
Shiozawa, Thomas	(n)	Int'l Poster #14
Shitaye, Hailu	(n)	Paper #14
Shonuga, Owolabi	(n)	Poster #157
Shuler, Michael S.	(1,2,6-Nonin Medical, Inc)	Paper #76; Poster #180
Sibai, Tarek	(n)	Paper #25
Sibonga, Raymar L.	(???)	Int'l Poster #1
Siegel, Judith A.	(7-Wolters Kluwer Health - Lippincott Williams & Wilkins)	Paper #9
Sietsema, Debra	(2,3B-Eli Lilly, 9-American Orthopaedic Association Own the Bone; Bone and Joint Initiative; Orthopaedic Trauma Association Coding and Classification Committee; NOF Nursing Advisory Council; NAON Evidence Base Practice and Research Committee; RN-AIM Research Council)	Papers #116, 117; Poster #172 Mini Symposium Faculty
Simon, David Andrew	(n)	Paper #70
Simone, Juan P.	(n)	Poster #89
Sims, Stephen H.	(5-Synthes, 9-AO Trauma North America Trauma Board; AO Trauma North America Education Committee NAMTEC)	Papers #63, 101
Sing, Ronald F.	(n)	Paper #63
Sirkin, Michael S.	(1,2,3B-Biomet, 7-Saunders/Mosby- Elsevier, 8-Journal of the American Academy of Orthopaedic Surgeons; Journal of Trauma; Journal of Orthopaedics and Traumatology, 9-Orthopaedic Trauma Association)	Poster #36; Mini Symposium Faculty
Siska, Peter	(n)	Posters #8, 155, 190
Sitzman, Thomas	(n)	Paper #51
Slobogean, Gerard P.	(5-Synthes, Stryker)	Paper #57; Posters #63, 150
Slone, Harris	(n)	Poster #75
Smeets, S.J.M.	(n)	Paper #38
Smith, Beth P.	(5-On a grant from MAKO that supports medical student research)	Poster #158
Smith, Carla S.	(2-AO Faculty; 8-JOT; 9-SIGN)	Lab Faculty
Smith, Carole	(n)	Poster #18
Smith, Clare	(n)	Paper #111

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DISCLOSURE LISTING – ALPHABETICAL

Smith, Emily K. ....	(???)	Paper #76; Poster #180
Smith, George .....	(n)	Paper #39
Smith, Jeffrey M. ....	(2-AO North America; .....	Mini Symposium Faculty <i>Medtronic, 3B-Smith &amp; Nephew; Medtronic; Stryker, 6-AO North America, 9-Orthopaedic Trauma Association (Public Relations Committee Chairman))</i>
Smith, Jordan .....	(n)	Poster #81
Smith, Wade R. ....	(2,3B,5-Synthes, 7-Mcgraw Hill, .....	Paper #30; 8-Journal of Trauma) .....
Smithson, Ian R. ....	(n)	Poster #162
Soham Banerjee, BS.....	(n)	Poster #66
Sokucu, Sami .....	(???)	Int'l Poster #23
Solberg, Brian D.....	(3B-Stryker)	Paper #88
Song, Daniel .....	(n)	Paper #47
Song, Yanna .....	(n)	Poster #122
Southeast Fracture Consortium	(n)	Paper #68
Soydan, Ramazan .....	(???)	Int'l Poster #23
Sprague, Sheila .....	(3A-Global Resarch Solutions Inc., 4-Eli Lilly) ..	Poster #146
Spratt, Kevin .....	(n)	Paper #96; Poster #106
SPRINT Investigators.....	(n)	Paper #114
Srivastava, Professor Rajeshwar	(???)	Int'l Poster #12
Stahl, Daniel L. ....	(n)	Paper #78
Stammers, J.....	(n)	Int'l Poster #22
Stannard, James P. ....	(2,3B-KCI; Medtronic Sofamor Danek, ....	Papers #16, 104; 3B-Sonoma; Smith & Nephew, .....
		Posters #51, 125 7-Theime, 8-Journal of .....
		Mini Symposium Faculty <i>Knee Surgery, 9-Orthopaedic Trauma Association)</i>
Starr, Adam J. ....	(1-Starrframe, LLC, 2-Smith & Nephew, ....	Posters #63, 66, 8-Journal of Orthopaedic Trauma) .....
		142, 144; ..... Mini Symposium Faculty
Steel, Jennifer .....	(n)	Poster #155
Steen, Brandon .....	(n)	Poster #16
Steinberg, Ely Liviu .....	(n)	Poster #3
Stephen, David J. ....	(3B,6-Synthes, 8-Journal of Bone and .....	Paper #64 <i>Joint Surgery - American; .....</i>
		Mini Symposium Faculty <i>Journal of Orthopaedics and Traumatology)</i>
Sterling, Robert .....	(n)	Paper #67
Sternheim, Amir .....	(n)	Poster #4
Stevenson, Andrew J.....	(???)	Int'l Poster #27

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## DISCLOSURE LISTING – ALPHABETICAL

Stinner, Daniel J. ....	(9-Society of Military Orthopaedic Surgeons; ....	Poster #41 <i>Orthopaedic Trauma Association)</i>
Stöckle, Ulrich .....	(n) .....	Int'l Poster #14
Stoffel, Marcus .....	(5-Stryker).....	Int'l Poster #16
Stolbrink, M. ....	(???) .....	Int'l Poster #27
Stone, Martin .....	(n) .....	Poster #118
Stoneback, Jason W. ....	(5-Synthes, 9-Orthopaedic Trauma Association) .	Poster #184
Stranks, Geoff .....	(n) .....	Poster #182
Strasser, Nicholas L. ....	(n) .....	Poster #47
Strassmair, Michael .....	(2-Stryker, 3C,5-Conventus Orthopaedics) ....	Poster #108
Stratton, Alexandra .....	(n) .....	Poster #105
Christina Rose		
Streubel, Philipp N. ....	(n) .....	Paper #73; ..... Posters #89, 164, 165
Strohecker, Kent .....	(n) .....	Poster #21
Stuart, Ami R. ....	(n) .....	Paper #107; Poster #55
Stuby, Fabian .....	(n) .....	Int'l Poster #14
Stucken, Charlton .....	(n) .....	Paper #95
Su, Edwin P. ....	(n) .....	Poster #9
Sucato, Dan .....	(9-POSNA, AAOS, SRS).....	Poster #175
Sugi, Michelle .....	(n) .....	Paper #82
Suk, Michael .....	(3B-Stryker, 6-Synthes, 8-American Journal .....	Paper #97 <i>of Orthopaedics, Military .....</i> Mini Symposium Faculty <i>Medicine, Journal of Trauma</i> <i>Management and Outcomes,</i> <i>9-Florida Orthopaedic Society, Orthopaedic Trauma</i> <i>Association, AO International)</i>
Sullivan, Jaron .....	(n) .....	Paper #17
Sun, Terri .....	(n) .....	Poster #150
Susarla, Seenu .....	(n) .....	Poster #47
Svarzchtein, Santiago .....	(n) .....	Posters #7, 159
Swiontkowski, Marc F. ....	(7-Saunders/Mosby).....	Mini Symposium Faculty, <i>-Elsevier; Wolters Kluwer .....</i> Case Presentation Faculty <i>Health - Lippincott Williams &amp; Wilkins,</i> <i>8-Journal of Bone and Joint Surgery - American)</i>
Switzer, Julie .....	(9-AAOS Women's Health .....	Poster #12 <i>Issues Advisory Board)</i>
Swygert, Kristin A. ....	(n) .....	Paper #114
Syed, Khalid .....	(n) .....	Paper #15
Symonds, Susanna .....	(n) .....	Paper #111
Szypryt, E. Paul .....	(???) .....	Paper #7
Tabaie, Sean .....	(n) .....	Paper #55

**Disclosure:**

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## DISCLOSURE LISTING – ALPHABETICAL

Takemoto, Richelle Carrie	..... (n)	..... Paper #82; Poster #161
Tank, Yeliz	..... (n)	..... Poster #85
Tarkin, Ivan S.	..... (2,5-Synthes; Zimmer)	..... Posters #8, 62, 65, 155, 190
Tavares, Ricardo Antonio	..... (???)	..... Int'l Poster #3
Taylor, Benjamin C.	..... (n)	..... Poster #152
Taylor, Julie	..... (n)	..... Poster #76
Teague, David C.	..... (8-Journal of Orthopaedics and Traumatology, 9-Center for Orthopaedic Trauma Advancement (COTA); Orthopaedic Trauma Association)	..... OTA Board
Tejwani, Nirmal C.	..... (1-Biomet, 2,3B-Zimmer; Stryker,	..... Papers #71, 82 9-AAOS; Orthopaedic Trauma Association; Federation of Orthopaedic Trauma)
Templeman, David C.	..... (1,2-Zimmer, 3B-Stryker, 3C-Biomet,	..... Paper #61 7-SLACK Incorporated, ..... Case Presentation Faculty; 9-Orthopaedic Trauma Association; SIGN) ..... OTA Board
Teter, Harry M.	..... (n)	..... Poster #139
Thakur, Nikhil Anand	..... (n)	..... Paper #4; Poster #19
Theocharakis, Stelios	..... (n)	..... Poster #118
Thungapathra, M.	..... (n)	..... Poster #192
Tiberi, John V.	..... (n)	..... Paper #77
Tilzey, John F.	..... (n)	..... Poster #16
Tintle, Scott Matthew	..... (n)	..... Poster #92
Tomlinson, Lauren A.	..... (n)	..... Paper #110
Tonne, Brian M.	..... (n)	..... Poster #72
Torchia, Michael E.	..... (n)	..... Poster #188
Tornetta, Paul, III.	..... (1,3B-Smith & Nephew,	..... Papers #6, 9, 25, 41; 7-Wolters Kluwer Health - ..... 45, 61, 95, 114; Lippincott Williams & Wilkins, ... Posters #32, 61, 111, 123; 8-Journal of Orthopaedic Trauma, ..... EBM Poster; 9-American Orthopaedic ..... Symposium Faculty; Association; Orthopaedic ..... Mini Symposium Faculty; Trauma Association) ..... Case Presentation Moderator
Törnkvist, Hans	..... (n)	..... Paper #29
Torres, João Batista Manzolli	..... (???)	..... Int'l Poster #3
Tosti, Richard	..... (n)	..... Poster #176
Tötterman, Anna	..... (n)	..... Paper #62
Toussaint, Rull James	..... (n)	..... Posters #42, 46, 47, 111
Tracey, Robert William	..... (n)	..... Poster #168
Tran, Wesley Huy	..... (n)	..... Paper #77
Trask, Kelly	..... (n)	..... Paper #28

**Disclosure:**

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## DISCLOSURE LISTING – ALPHABETICAL

Truwit, Chip	(3C-Medical Advisory Boards, Philips Healthcare)	Symposium Faculty
Tsahakis, James M.	(n)	Poster #116
Tucker, Michael C.	(n)	Paper #32
Tuinebreijer, Wim	(n)	Poster #85
Tutton, Elizabeth	(n)	Paper #111
Ubbink, Dirk T.	(n)	Poster #53
Uppal, Harmeeeth	(n)	Paper #16
Vafek, Emily	(n)	Poster #32
Vaidya, Rahul	(2,5,6-Synthes, 2,3B,3C-Stryker, 8-European Spine Journal)	Posters #69, 88 Mini Symposium Faculty
Vallier, Heather A.	(8-Journal of Orthopaedics and Traumatology, 9-Orthopaedic Trauma Association)	Papers #8, 9, 43, 102; Posters #110, 140, 156 Case Presentation Faculty; OTA Board
Van Dijkman, Bart	(n)	Paper #93
VanderHave, Kelly L.	(n)	Moderator
Vang, Sandy	(n)	Poster #12
Vaughan, Asa	(n)	Paper #21
Vaupel, Zack	(n)	Paper #42
Veh, Juliane	(n)	Poster #148
Venezia, Robert	(n)	Poster #130
Verbruggen, Jan	(9-Küntscher Society)	Paper #38
Vetrovec, Diane	(n)	OTA Staff
Vicente, Milena (Lynn)	(n)	Papers #87, 91
Vigdorichik, Jonathan	(n)	Poster #69
Villarreal, Jaime, Jr.	(n)	Poster #45
Vinje, Tarjei	(n)	Paper #27
Vlasak, Andrea J.	(n)	Poster #12
Volgas, David A.	(n)	Papers #16, 104; Posters #51, 125
Vopat, Bryan	(n)	Paper #109
Vrahas, Mark S.	(4-Pioneer Medical, 8-Clinical Orthopaedics and Related Research, 9-AO Foundation)	Paper #33, 72; Poster #111
Wagner, Eric R.	(n)	Poster #103
Wakefield, Jennie	(n)	Paper #111
Wakeman, Robert	(???)	Poster #27
Walcott, Marie E.	(n)	Paper #12
Wall, Eric J.	(3C-Orthopediatrics Sports Medicine, 9-Pediatric Orthopaedic Society of North America)	Poster #177
Walsh, Thomas	(???)	Poster #108
Walton, Zeke	(n)	Poster #75
Wang, Dong	(???)	Paper #34

**Disclosure:**

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## DISCLOSURE LISTING – ALPHABETICAL

Wang, Eric A. ....	(n) .....	Paper #63
Wang, Hao .....	(3A,4-Semprus Biosciences) .....	Paper #22
Wang, Luojun .....	(n) .....	Paper #89; Poster #94
Wang, Stewart .....	(n) .....	Paper #58; Poster #61
		Symposium Faculty
Wanger, Scott C. ....	(n) .....	Poster #169
Wasserstein, David .....	(n) .....	Paper #80
Watson, J. Tracy .....	(1-DePuy, A Johnson & Johnson ... Company, 1,3B-Smith & Nephew, ... 2-Medtronic; Stryker, ... 3C-Accelalox; Ellipse, ... 8-Ortho Knowledge Online, ... 9-Orthopaedic Trauma Association)	Papers #13, 32, 68, 69; Posters #1, 32, 54, 184 Moderator, Mini Symposium Faculty, Lab Moderator
Weaver, Michael J. ....	(2-Synthes) .....	Paper #72; Posters #50, 111
Webb, Lawrence X. ....	(2-Musculoskeletal Transplant Foundation, 3B-Zimmer, 6-Synthes; Smith & Nephew; Stryker; Kinetic Concepts, Doctors Group, 9-Orthopaedic Trauma Association Southeastern Fracture Consortium Foundation)	Lab Faculty
Weber, Timothy .....	(2-AO North America, 9-AO Foundation Trustee) .	Poster #1
Wedel, Cindy .....	(n) .....	Poster #126
Weening, Alexander .....	(n) .....	Paper #93
Wegener, Stephen .....	(n) .....	Poster #122
Weil, Yoram A. ....	(n) .....	Poster #33;
		Int'l Poster #10
Weiss, David .....	(n) .....	Paper #32
Wellman, David S. ....	(3B-Synthes Dynamic Locking Screw) .....	Posters #9, 77
Wenke, Joseph C. ....	(5-Bionova Medical, Inc., ... 8-Tissue Engineering) .....	Papers #52, 53, 54, 99; Poster #186;
		Symposium Faculty
West, R. M. ....	(3B-Stryker Europe; ... 5-DePuy, Stryker, Synthes, Amgen)	Int'l Poster #18
Westberg, Jerald .....	(n) .....	Paper #9; Poster #87
Wharton, Rupert .....	(n) .....	Int'l Poster #31
White, Raymond R. ....	(1,2-Zimmer) .....	Lab Moderator
White, Timothy O. ....	(3B,5,6-Acumed, LLC) .....	Papers #39, 40, 44, 92; Posters #28, 57
Whitesides, Thomas E., Jr. ....	(n) .....	Paper #76
Wilber, John H. ....	(2-Synthes, 9-Orthopaedic Trauma Association; AONA. AOFoundation)	Poster #110
Wilber, Roger G. ....	(2-Synthes, 9-AO North America) .....	Lab Faculty

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## DISCLOSURE LISTING – ALPHABETICAL

Wilde, Erik	(n)	Poster #15; Int'l Poster #29
Will, Elizabeth M.	(n)	Poster #97
Will, Ryan E.	(n)	Paper #86
Willett, Keith M.	(1-Royalties from Zimmer, 5-PI for AMGEN trial)	Paper #111; Poster #27; Int'l Poster #31; Symposium Faculty
Williams, Seth K.	(3B-DePuy, A Johnson & Johnson Company)	Papers #1, 56
Wilson, Frederic B., Jr.	(9-AAOS, SIGN)	Lab Faculty
Wilson, Kevin William	(n)	Poster #92
Wilson, Lindsay M.	(n)	Poster #177
Wimberly, Robert L.	(n)	Case Presentation Faculty
Windolf, Markus	(n)	Int'l Posters #14 & 15
Wing, Lau Tak	(???)	Symposium Faculty
Winger, Dan G.	(n)	Poster #8
Wixted, John J.	(n)	Paper #12
Wolinsky, Philip R.	(2-Zimmer, 3B-Biomet; Zimmer, 8-Journal of Orthopedic Trauma, 9-Orthopaedic Trauma Association; AAOS, AOA)	Symposium Faculty, Case Presentation Faculty
Wood, Jennifer H.	(n)	Paper #32
Woodbury, Ashley	(n)	Paper #107
Wright, Raymond D., Jr.	(n)	Posters #59, 112
Wyrick, John D.	(3B-Stryker)	Poster #11
Wysocki, Elizabeth	(n)	Poster #139
Yang, King	(n)	Poster #69
Yang, Scott	(n)	Paper #32
Yannascoli, Sarah	(n)	Poster #117
Ying, Jun	(n)	Paper #108
Yoneda, Zachary T.	(n)	Posters #109, 124
Yoon, Richard S.	(n)	Poster #39
Young, Matt	(n)	Poster #19
Yu, Baoqing	(???)	Int'l Poster #7
Yu, Yan Yiu	(n)	Paper #10
Yuan, Brandon	(n)	Poster #101
Zadnik, Mary	(n)	Poster #139
Zamarano, David	(2-AO North America, 2,5-Synthes 3B,5-Smith & Nephew, 5-Amgen)	Poster #1
Zdero, Rad	(n)	Paper #5; Poster #90
Zeidler, Suzanne	(n)	Int'l Poster #31
Zeitler, Evan M.	(n)	Paper #49

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## DISCLOSURE LISTING – ALPHABETICAL

Zeng, Bingfang	..... (n) .....	Paper #34
Zhang, Zjuin	..... (n) .....	Paper #13
Ziran, Bruce H.	..... (2-Stryker, 3B-Synthes,.....	Case Presentation Faculty 4-Symbod; Tekartis, 8-Clinical Orthopaedics and Related Research; Journal of Bone and Joint Surgery - American; Journal of Orthopaedics and Traumatology; Journal of Trauma; Patient Safety in Surgery)
Zirkle, Lewis G.	..... (3C-SIGN, 8-Orthoprenour,.....	Lab Moderator 9-Orthopaedic Trauma Association- International Committee)
Zuiderbaan, Aernout	..... (n) .....	Poster #84
Zura, Robert D.	..... (2,3B,5-Smith & Nephew,.....	Symposium Faculty, 5-Synthes, 6-Synthes Fellowship) Mini Symposium Faculty
Zurakowski, David	..... (n) .....	Paper #72
Zurmehly, Keith.	..... (???) .....	Mini Symposium Faculty

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**BSFF SYMPOSIUM 1:  
BIOMECHANICALLY-DIRECTED FIXATION: HOT TOPICS**

**Moderators:** *Emil H. Schemitsch, MD*  
*Joan E. Bechtold, PhD*

- 7:30 am      **Clavicle Plating: Should It Be Superior or Anterior?**  
*Michael D. McKee, MD*
- 7:38 am      **Proximal Humerus: What Is the Ideal Fixation Construct?**  
*Michael J. Gardner, MD*
- 7:46 am      **Distal Humerus: Parallel or Perpendicular Plating?**  
*Emil H. Schemitsch, MD*
- 7:54 am      **Nail vs. Plating for IT Hip Fractures: What Is the Biomechanical Evidence?**  
*Kenneth A. Egol, MD*
- 8:02 am      **Distal Femur: Retrograde Nail or Locked Plate?**  
*Philip J. Kregor, MD*
- 8:10 am      **Proximal Tibia: How Many Plates are Enough?**  
*Philip R. Wolinsky, MD*
- 8:18 am      Discussion

PAPER ABSTRACTS

NOTES

- The FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use). For full information, refer to page 619.

**Biomechanics of Short-Segment Fixation in an Unstable Thoracolumbar Flexion-Distracton Injury Model: Six-Screw Construct With and Without Facet Compression**

**Robert P. Norton, MD<sup>1</sup>; Edward L. Milne<sup>2</sup>; David N. Kaimrajh, MS<sup>2</sup>; Frank J. Eismont, MD<sup>1</sup>; Loren L. Latta, MD, PhD<sup>1,2</sup>; Seth K. Williams, MD<sup>1</sup>;**

<sup>1</sup>*Department of Orthopaedics, University of Miami, Miami, Florida, USA;*

<sup>2</sup>*Max Biedermann Institute for Biomechanics, Miami Beach, Florida, USA*

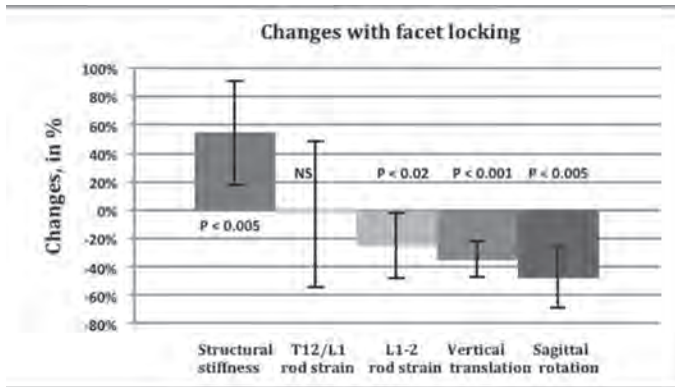
**Background/Purpose:** Flexion-distracton injuries (FDIs) typically result in compression failure of the anterior column and tension failure of the posterior column. Unstable injuries with disruption of the posterior ligamentous complex (PLC) are best managed with posterior instrumented fusion; however, the length and type of construct is debatable. This study analyzes the biomechanical effects of six-screw short-segment constructs with and without compression through the facets in a cadaveric L1 FDI model.

**Methods:** Seven fresh-frozen human cadaver spines from T12 to L2 were used for testing. A compression fracture with loss of at least 50% height was produced at L1. The PLC was transected with a scalpel. The specimens were instrumented from T12 to L2 with 6-mm pedicle screws connected to 5.5-mm titanium rods. LED emitters were fixed to the T12 and L2 to measure their 6 degrees of freedom motions. From those measures, the relative motion between T12 and L2 could be calculated. Uniaxial strain gauges were bonded to the open segment of the rods between T12 and L1, and also between L1 and L2. A 400-N follower preload simulated the forces of the paraspinal musculature. Specimens were cyclically loaded from 5 N·m extension to 5 N·m flexion, well within their elastic range. Two conditions were tested: (1) six-screw construct without compression across the facets and (2) six-screw construct with compression across the T12-L1 and L1-L2 facets. Structural stiffness in flexion and extension, rod strain, vertical translation, and sagittal rotation were all evaluated. The measurements for each condition were compared by the paired Student *t*-test.

**Results:** Due to specimen variability, the differences in absolute numbers measured were not significant. However, paired sampling by percent change of each measure related to the facet condition resulted in a 54.5% increased structural rigidity ( $P < 0.005$ ), 34.9% reduction in vertical translation ( $P < 0.0005$ ), a 48.2% reduction in sagittal rotation ( $P < 0.005$ ), and a 25.7% reduction in L1-L2 rod strain ( $P < 0.02$ ).

**Discussion:** This is the first biomechanical study to evaluate the effects of instrumentation with compression across the facets in a cadaveric FDI model. Compression of the posterior instrumented construct through the facets significantly improves construct rigidity and may improve alignment and stability in the setting of an unstable FDI.

**Significance:** When both the anterior and posterior columns are unstable, achieving rigid fixation is challenging. Intact facet joints that articulate with the “floating” segment at L1 provide the best opportunity to restore intrinsic stability to the T12 and L2 segments. By compressing the facet joints with the posterior rod and pedicle screw construct, one can best reestablish stability to the posterior column, thus decreasing the chance of mechanical failure.



**Figure:** The % change for each parameter in each spine with versus without compression across the facet joints.

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**Optimizing the Biomechanics of Iliosacral Screw Fixation: The Importance of Washers and Avoiding Lateral Cortex Perforation**

*Julius A. Bishop, MD; Anthony W. Behn, MS; Tiffany N. Castillo, MD;  
Stanford University Medical Center, Palo Alto, California, USA*

**Purpose:** Percutaneous iliosacral screws are frequently used to stabilize posterior pelvic ring injuries and can be placed with or without washers. Because the cortical bone of the outer table of the posterior ilium is thin, it is possible for the surgeon to unintentionally perforate this cortex during screw insertion, theoretically compromising fixation. The purpose of this study was to detail the biomechanical consequences of washer use and iliosacral screw intrusion.

**Methods:** Partially threaded 7.0-mm cannulated screws with and without washers were placed through a synthetic bone test block fabricated to approximate the cortical and cancellous bone of the posterior ilium. A load cell was used to measure the compression generated before and after perforation of the outer cortex. 24 screws were tested under three different conditions: with a washer, without a washer, and with a washer after intrusion.

**Results:** Screws inserted with washers generated significantly more compressive force than screws inserted without washers before screw intrusion. After intrusion, compressive force decreased significantly under all conditions but screws inserted with washers maintained greater compressive force than screws inserted without washers. After intrusion of screws without washers, screws with washers reinserted through the same holes produced almost as much compressive force as screws inserted with washers primarily.

**Conclusions:** Screw intrusion during iliosacral screw insertion can compromise fixation quality. Washers are advantageous in that they allow for more compression to be generated before intrusion occurs and can be used to salvage intruded screws initially placed without them. Washers can also be monitored fluoroscopically as they seat against the ilium, providing an additional safeguard against intrusion.



### Screw Stripping: Can We Trust the “Bailout” Screw?

*Amir Matityahu, MD; Gudrun Mirick, MD; Meir Marmor, MD;  
Orthopaedic Trauma Institute, San Francisco General Hospital,  
University of California San Francisco, San Francisco, California, USA*

**Background/Purpose:** Cortical stripping of 3.5-mm screws is a common occurrence during osteosynthesis especially in osteoporotic bone. Tightening the screw beyond the ultimate insertion torque will cause stripping of the screw with an associated reduction of 80% of its pullout strength. Once stripping of a 3.5-mm cortical screw occurs, a “bailout” 4.0-mm cancellous screw can be inserted in its place. Ideally the “bailout” screw would replicate the original insertion torque of the primary cortical screw. The adequacy of the screw exchange is appreciated clinically by many surgeons. However, using a “bailout” screw has not been previously examined biomechanically. The aim of this study was to quantify the ability of a “bailout” screw to restore the original insertion torque in a stripped 3.5-mm cortical screw hole.

**Methods:** Four different types of bone surrogates representing normal cortical bone (NCBS), osteoporotic cortical bone (OCBS), high-density (normal) cancellous bone (HDCBS), and low-density (osteoporotic) cancellous bone (LDCBS) were used. A 2.5-mm drill bit was used to drill 25 “bicortical” holes in each surrogate. Each hole was then stripped using a 3.5-mm cortical screw. Screw stripping was verified by clinical judgment and real-time screw insertion torque measurements. A 4.0-mm cancellous screw was then inserted into the stripped hole and maximal insertion torque (MIT) was measured before allowing the screw to strip.

**Results:** The “bailout” screw was able to restore 100% of insertion torque in NCBS, 58% of insertion torque in OCBS, and only 41% of insertion torque in HDCBS. In LDCBS, insertion torques were restored but were generally very low for both the initial and the “bailout” screw (table).

**Conclusions:** In all but normal cortical bone, use of 4.0-mm cancellous “bailout” screws does not regain all of the initial 3.5-mm cortical screw insertion torque. In the severely osteoporotic bone surrogate, the primary cortical screw and the “bailout” have low insertion torques and should probably not be relied on for fixation.

**Table** Maximal screw insertion torque measurements in N-cm

Bone Model	Initial Insertion	“Bailout” Screw	% of MIT Restored	Student <i>t</i> Test
LD foam (LDCBS)	21 ± 4	20 ± 5	97%	<i>P</i> = 0.809
HD foam (HDCBS)	139 ± 53	57 ± 25	41%	<i>P</i> = 1e-06
Foam + shell SB (OCBS)	130 ± 13	76 ± 16	58%	<i>P</i> = 1e-07
Composite 4 <sup>th</sup> -generation SB (NCBS)	301*	301*	100%	

SB = Sawbone®

\*MIT measurement exceeded 300 N-cm. Further increase in torque is clinically unnecessary.

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## Intertrochanteric Fracture Optimal Lag Screw Placement Revisited: A Biomechanical Study

Patrick M. Kane, MD<sup>1</sup>; Wendell M.R. Heard, MD<sup>2</sup>; Nikhil Thakur, MD<sup>3</sup>; David Paller, MS<sup>4</sup>; Sarath Koruprolu, MS<sup>4</sup>; Christopher T. Born, MD<sup>1</sup>;

Department of Orthopaedic Surgery, Brown University, Rhode Island Hospital, Providence, Rhode Island, USA;

<sup>2</sup>Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, Illinois, USA;

<sup>3</sup>Department of Orthopaedic Surgery, Emory University, Atlanta, Georgia, USA;

<sup>4</sup>RIH Orthopaedics Foundation, Inc, Providence, Rhode Island, USA

**Purpose:** Low-center (L-C) lag screw position in the femoral head, with a tip apex distance (TAD) >25 mm will provide equal, if not superior, biomechanical stability compared to a center-center (C-C) position with a TAD <25 mm, in an unstable intertrochanteric hip fracture stabilized with a long cephalomedullary intramedullary nail.

**Methods:** 20 human femur samples, 10 matched pairs, were dual-energy x-ray absorptiometry (DEXA)-scanned and then assigned to one of two treatment groups: L-C lag screw position (lefts) and C-C lag screw position (rights). Cephalomedullary intramedullary nails (Stryker Long Gamma 3) with a single dynamic interlocking screw were placed using fluoroscopy. Radiographs were obtained to confirm proper implant placement, low or centered on the AP and centered on the lateral. TAD was measured. A standard unstable four-part intertrochanteric fracture was created in all samples. Custom marker flags for use with the Optotrak system (Northern Digital) were secured to the proximal fracture fragment, distal fracture fragment, lag screw, and femur distal to the interlock screw. The femoral head and distal femur were potted in urethane (Smooth On) and axially loaded using an MTS 810 servohydraulic load frame. The femurs were loaded dynamically until failure, defined as >1.5 cm of height loss. Load and displacement data were recorded as well as three-dimensional motion using Optotrak motion tracking system. Kaplan-Meier survival analysis, Mantel-Cox log rank, Gehan-Breslow-Wilcoxon, and paired Student *t* test statistical analysis was performed. In all tests statistical significance was set to  $P < 0.05$ .

**Results:** The three-dimensional kinematic data showed statistically significant increased motion in the C-C group compared to the L-C group. At the time of failure, the magnitude of fracture translation was statistically significantly higher in the C-C group ( $19.82 \pm 2.77$  mm) compared to the L-C group ( $15.24 \pm 3.39$  mm,  $P = 0.004$ ). Additionally there was statistically significant increased fracture gap distraction (C-C group:  $12.72 \pm 2.84$  vs. L-C group:  $6.56 \pm 3.98$ ,  $P < 0.001$ ) and shear fracture gap translation (C-C group:  $11.45 \pm 2.33$  mm, L-C group:  $5.54 \pm 2.69$  mm,  $P < 0.001$ ). There was no statistically significant difference between the L-C and C-C treatment groups with regard to mean number of cycles to failure and mean failure load.

**Conclusion:** Positioning of the lag screw inferior in the head and neck proved to be at least as biomechanically stable as the C-C group even though the TAD was >25 mm. Additionally, using a lower angle nail lag screw construct may be safer and reduce the chances of cut-out.

## Biomechanical Measurements of Cyclic Preconditioning on Cadaveric Whole Canine Femurs

Emil H. Schemitsch, MD<sup>1,2</sup>; Chris H. Gallimore, MD<sup>2</sup>; Alison J. McConnell<sup>3</sup>; Harshita Patel, DDS<sup>4</sup>; Rosane Nisenbaum, PhD<sup>5</sup>; Golam Morshed<sup>4</sup>; Henry Koo, MD<sup>6</sup>; Michael D. McKee, MD<sup>2</sup>; Habiba Bougherara, PhD<sup>4</sup>; Rad Zdero, PhD<sup>1,4</sup>;

<sup>1</sup>Biomechanics Laboratory, St. Michael's Hospital, Toronto, Ontario, Canada;

<sup>2</sup>Department of Surgery, Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada;

<sup>3</sup>Medtronic International Trading Sàrl, Tolochenaz, Switzerland;

<sup>4</sup>Dept. of Mechanical and Industrial Engineering, Ryerson University, Toronto, Ontario, Canada;

<sup>5</sup>Centre for Research on Inner City Health, Applied Health Research Centre, St. Michael's Hospital, Toronto, Ontario, Canada;

<sup>6</sup>Collingwood General and Marine Hospital, Collingwood, Ontario, Canada

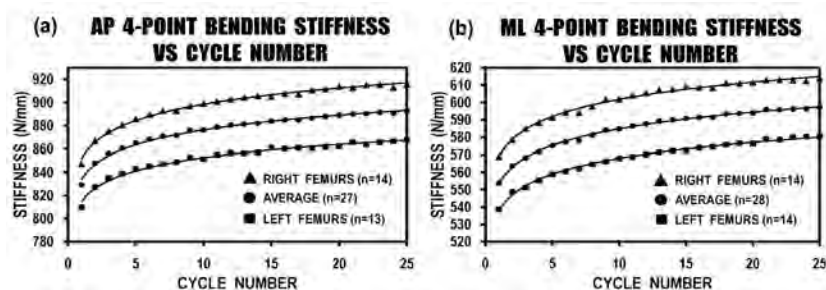
**Purpose:** Biomechanical preconditioning of specimens by cyclic loading is often done theoretically to stabilize properties prior to the main phase of an investigation. However, no previous studies have measured these effects for whole bone of any type. The purpose of this study was to quantify these effects for whole bones.

**Methods:** 14 matched pairs of fresh-frozen canine whole femurs were sinusoidally loaded in 4-point bending from 50 N to 300 N at 1 Hz for 25 cycles in anteroposterior (AP) and mediolateral (ML) bending. Stiffness and linearity  $R^2$  of each cycle were measured to determine the effect of limb side, test type, and cycle number.

**Results:** Stiffnesses rose from 809.7 to 867.7 N/mm (AP, left), 847.3 to 915.6 N/mm (AP, right), 538.7 to 580.4 N/mm (ML, left), and 568.9 to 613.8 N/mm (ML, right).  $R^2$  rose from 0.96 to 0.99 (AP, left), 0.97 to 0.99 (AP, right), 0.95 to 0.98 (ML, left), and 0.94 to 0.98 (ML, right). Stiffness and  $R^2$  versus cycle number were well-described by exponential curves, whose values leveled off starting at 12 cycles and onward (see figure). For stiffness, there was no statistically significant difference for left versus right femurs ( $P = 0.166$ ), but there was an effect for AP versus ML test mode ( $P < 0.0001$ ) and cycle number ( $P < 0.0001$ ). For  $R^2$ , no significant difference was noted due to limb side ( $P > 0.05$ ) or test mode ( $P > 0.05$ ), but there was an effect due to cycle number ( $P < 0.05$ ).

**Conclusions:** A minimum of 12 preconditioning cycles is required to stabilize the mechanical properties of whole bone. This is the first investigation to quantify these effects on whole bone of any kind.

**Figure**  
Stiffness versus cycle number for (a) AP and (b) ML bending.



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## Mechanical Behavior and Failure Mode for Cross-Threaded Locking Screws

Jacob L. Cartner, MS, Tim Petteys, MS<sup>1</sup>; Paul Tornetta III, MD<sup>2</sup>;

<sup>1</sup>Smith & Nephew, Memphis, Tennessee, USA;

<sup>2</sup>Boston University School of Medicine, Boston, Massachusetts, USA

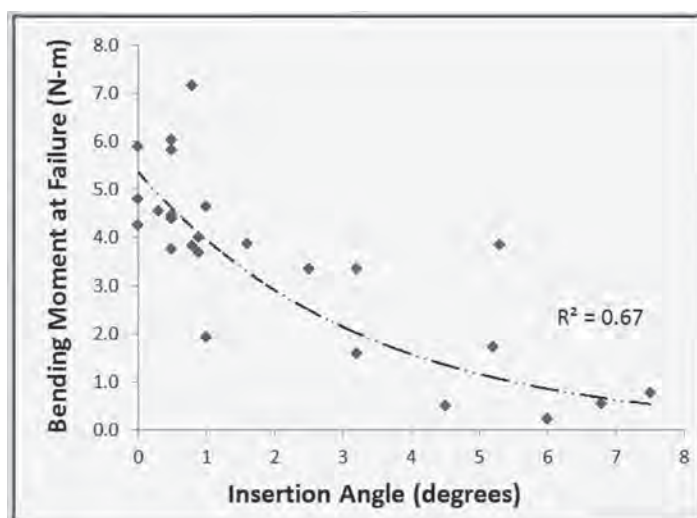
**Purpose:** Locking screws have proven strength when placed orthogonal to the plate, but certain fracture lines and/or poor bone quality have led some to intentionally cross-thread traditional locking screws in a nonorthogonal manner in order to capture offside bone fragments. However, the biomechanical consequences of this practice have not been addressed. The purpose of this study was to evaluate the cantilevered bending strength, screw head prominence, and failure mode of locking screws inserted at various angles in relation to the plate.

**Methods:** 25 3.5-mm Locking Cortex Screws (Smith & Nephew) were inserted into round holes through a straight plate via hand-powered insertion using a standard screwdriver. Screws were inserted to 1.7 N-m at various angles in relation to the longitudinal axis of the plate (ie, cross-threaded) and parallel to the transverse axis of the plate. Upon insertion, the achieved angle of insertion and its prominence protruding from the far-bone side of the plate was measured using optical luminescence. Each screw was then loaded until failure in a cantilevered bending scenario that simulated cortical fixation. Failure was defined as screw deformation or screw head disengagement. The failure mode and applied load at failure were noted.

**Results:** There was a positive correlation between increasing insertion angle and increasing prominence; a higher screw insertion angle yielded greater prominence ( $P < 0.05$ ). Conversely, as screw insertion angle increased, the bending moment at failure also increased ( $R^2 = 0.67$ , see figure). Screws inserted to  $3^\circ$  or below primarily failed via screw deformation at the minor diameter below the head (95% of the time), whereas screws inserted to  $>3^\circ$  primarily failed via locking mechanism disengagement (83% of the time).

### Figure:

Cantilevered bending strength of locking screws inserted off-axis.



See pages 97 - 144 for financial disclosure information.

**Conclusions:** Cross-threading locking screws results in decreased mechanical strength when evaluated in cantilevered bending. Failure mode also changed with off-axis insertion since screws inserted to  $>3^\circ$  off-axis in this study resulted in locking mechanism disengagement. Cross-threading also results in greater screw head prominence, which may lead to soft-tissue irritation in some anatomic areas. These findings indicate that the practice of cross-threading locking screws may not be mechanically advantageous.

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**BSFF SYMPOSIUM 2:  
VENOUS THROMBOEMBOLISM**

**Moderators:** *Steven A. Olson, MD*  
*William H. Geerts, MD*

9:55 am      **Prophylaxis in Trauma Patients: What is the Standard?**  
*H. Claude Sagi, MD*

10:05 am      **Thromboembolic Agents: The Present and the Future**  
*William H. Geerts, MD*

10:20 am      **Current Public Reported Metrics for VTE Prophylaxis:  
Are they Optimal?**  
*Steven A. Olson, MD*

10:30 am      **VTE and PE Treatment: Current Recommendations**  
*Robert D. Zura, MD*

10:45 am      Discussion

NOTES

PAPER ABSTRACTS

**Nottingham Trauma Symptomatic Venous Thromboembolism Risk Score (NotSVTE): Predicting Venous Thromboembolism in Acute Trauma Admissions. A Multicenter Validated Risk Score Based on 13,347 Serial Admissions**

*Benjamin J. Ollivere, FRCS, MBBS, MD<sup>1</sup>; Katie E. Rollins, MBBS<sup>1</sup>; E. Paul Szypryt, MBBS<sup>2</sup>; Christopher G. Moran, MD, FRCS<sup>1</sup>; Philip Johnston, MD<sup>1</sup>; James M Hunter, MD<sup>2</sup>;*

*<sup>1</sup>Cambridge University Teaching Hospitals NHS Trust;*

*<sup>2</sup>Nottingham University Teaching Hospitals NHS Trust*

**Background/Purpose:** Symptomatic venous thromboembolism (SVTE) is a potentially significant complication that may occur following injury or surgery. Recent guidelines, and a further push by medical negligence cases, have resulted in a clinical focus on decreasing in-hospital death from acquired SVTE. Despite this, there are no large studies investigating the risk factors for or incidence of SVTE in acute trauma admission.

**Methods:** Data from a prospective series of 9167 consecutive patients with a diagnosis of fractured neck of femur (NOF) at a single institution were used to construct a risk score for SVTE. 23 factors were screened with pairwise analysis for potential association with SVTE. The cohort had an event rate of 1.4%. A multiple logistic regression model was used to construct a risk score and correct for confounding variables from nine significant factors identified by the pairwise analysis. Four factors (length of stay, chest infection, cardiac failure, and transfusion) were used to produce the final risk score. The score was statistically significant ( $P < 0.0001$ ) and highly predictive (receiver operating curve [ROC] analysis, area under the curve [AUC] = 0.76) of SVTE.

**Results:** The score was separately validated in two cohorts from different Level I trauma centers. In one prospective consecutive cohort of 1000 NOF patients, all components of the Nottingham SVTE score were found to be individually statistically significant ( $P < 0.0045$ ). The score was further validated in a separate cohort of 3200 patients undergoing elective hip surgery. The score was found to be statistically significantly predictive of SVTE as a whole, and three of the four components were individually predictive in this patient cohort.

**Conclusions:** Balancing risks and benefits for thromboprophylaxis is key to reducing the risk of thromboembolic events, minimizing bleeding and other complications associated with the therapy. Our study of 13,367 prospective patients is the largest of its type and we have successfully constructed and validated a scoring system that can be used to inform patient treatment decisions.

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### **Δ Pulmonary Complications Are Reduced With a Protocol to Standardize Timing of Fixation Based on Response to Resuscitation**

*Heather A. Vallier, MD; Timothy A. Moore, MD; John J. Como, MD;*

*Patricia A. Wilczewski, RN, BSN; Michael P. Steinmetz, MD; Karl G. Wagner, MD;*

*Charles E. Smith, MD; Xiaofeng Wang, PhD; Andrea J. Dolenc, BS;*

*MetroHealth Medical Center, Cleveland Ohio, USA*

**Purpose:** Previous work has shown that early stabilization of femur, pelvis, acetabulum, and spine fractures minimizes pulmonary and other complications, while damage control tactics may provide provisional stability in patients unstable to tolerate definitive surgery. We developed a protocol to determine timing of definitive fracture care based on the presence and severity of acidosis. The purpose of this project was to prospectively assess the safety and feasibility of this protocol, defined as Early Appropriate Care (EAC). We hypothesized that EAC would be associated with fewer complications than a historical cohort of similar patients and that EAC patients treated definitively for their fractures of interest within 36 hours of injury would have fewer complications than those who were treated on a delayed basis.

**Methods:** We prospectively identified 185 skeletally mature patients with ISS>16 and 206 fractures of the proximal or diaphyseal femur (n = 81), pelvic ring (n = 34), acetabulum (n = 25), and/or spine (n = 66) treated between October 2010 and November 2011. The EAC protocol recommended definitive fixation of these fractures within 36 hours of injury, as long as initial acidosis had improved to lactate <4.0 mm/L, pH ≥7.25, or base excess (BE) ≥-5.5mmol/L. During persistent acidosis, damage control was recommended. Complications including infections, sepsis, deep vein thrombosis (DVT), organ failure, and pulmonary complications: pneumonia, acute respiratory distress syndrome (ARDS), and pulmonary embolism (PE) were identified. Initial hospital and ICU stay and readmissions were measured. Propensity score matching approach was used for adjustment of observational sampling bias to account for confounding variables including age and presence and severity of other injuries (chest, abdomen, and head). Pearson's likelihood ratio and Cochran-Mantel-Haenszel  $\chi^2$  tests were then applied for analysis of stratified categorical data.

**Results:** 135 men and 50 women with mean age of 40.7 years and mean ISS of 26.0 were included: 145 treated within 36 hours according to the EAC protocol, and 40 treated on a delayed basis. Complications occurred in 20% of patients treated within 36 hours and in 43% of delayed patients, while pulmonary complications occurred in 10% and 15%, respectively. This entire group of patients was compared with a historical cohort of 1443 similar patients with 1745 fractures treated at the same hospital between 2000 and 2007. EAC patients had fewer pulmonary complications (11% vs 24%,  $P = 0.001$ ) and fewer total complications (25% vs 31%,  $P = 0.17$ ). When comparing the EAC patients treated within 36 hours with those patients in the historical cohort also treated on an early basis, fewer pulmonary complications (10% vs 19%,  $P < 0.05$ ) and fewer total complications (20% vs 25%,  $P = 0.32$ ) were noted with EAC.

Δ OTA Grant

See pages 97 - 144 for financial disclosure information.



**Conclusion:** Fixation of mechanically unstable fractures of the femur, pelvis, acetabulum, and spine decreases pain and promotes mobility from a recumbent position, minimizing pulmonary complications. Definitive stabilization should occur when patients are adequately resuscitated to prevent a deleterious reactive systemic inflammatory response. Our protocol recommends definitive fixation within 36 hours in resuscitated patients. All 185 patients had achieved the desired level of resuscitation within that time. Early fracture care resulted in fewer complications in EAC patients, and EAC patients had fewer pulmonary complications than our historical group, when controlling for age, timing of fixation, and severity of other injuries, suggesting improvement with a standardized protocol to assess adequacy of resuscitation. The EAC recommendations appear safe and deserve further study.

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## Treatment and Complications in Orthopaedic Trauma Patients With Pulmonary Embolism

*Yelena Bogdan, MD<sup>1</sup>; Paul Tornetta, III, MD<sup>1</sup>; Ross K. Leighton, MD<sup>2</sup>; H. Claude Sagi, MD<sup>3</sup>; Charles C. Nalley, MD<sup>3</sup>; David W. Sanders, MD<sup>4</sup>; Judith A. Siegel, MD<sup>5</sup>; Brian H. Mullis, MD<sup>6</sup>; Thomas B. Bemenderfer, MD<sup>6</sup>; Heather A. Vallier, MD<sup>7</sup>; Alysse Boyd, MA<sup>7</sup>; Andrew H. Schmidt, MD<sup>8</sup>; Jerald R. Westberg, BS<sup>8</sup>; Kenneth A. Egol, MD<sup>9</sup>; Stephen A. Kottmeier, MD<sup>10</sup>; Cory A. Collinge, MD<sup>11</sup>; Robert A. Probe, MD<sup>11</sup>;*

<sup>1</sup>*Boston Medical Center, Boston, Massachusetts, USA;*

<sup>2</sup>*Dalhousie University, Halifax, Nova Scotia, Canada;*

<sup>3</sup>*Tampa General Hospital, Tampa, Florida, USA;*

<sup>4</sup>*London Health Sciences Center, London, Ontario, Canada;*

<sup>5</sup>*University of Massachusetts, Worcester, Massachusetts, USA;*

<sup>6</sup>*Indiana University-Purdue, Indianapolis, Indiana, USA;*

<sup>7</sup>*MetroHealth Medical Center, Cleveland, Ohio, USA;*

<sup>8</sup>*Hennepin County Medical Center, Minneapolis, Minnesota, USA;*

<sup>9</sup>*NYU Medical Center, New York, New York, USA;*

<sup>10</sup>*Stony Brook University Health Sciences Center, Stony Brook, New York, USA;*

<sup>11</sup>*Texas Health Fort Worth, Fort Worth, Texas, USA*

**Background/Purpose:** No data exist specifically reviewing the diagnosis and treatment of pulmonary embolism (PE) in orthopaedic trauma patients. Recent evidence suggests that advanced diagnostic methods such as CT pulmonary angiography (CTPA) are able to diagnose very small clots, such as subsegmental, which are of questionable clinical relevance. Furthermore, PE, both in symptoms and in size, is a spectrum as is its treatment. A “one size fits all” approach to treating PEs, therefore, may affect patient outcomes. The purpose of this study is to characterize the presentation, size, treatment, and complications in a large series of orthopaedic trauma patients who developed PE after injury. This is the first such evaluation.

**Methods:** We reviewed the records of orthopaedic trauma patients who developed a PE within 6 months of injury at 10 trauma centers. The data were grouped into: demographics/history (age, body mass index [BMI], sex, prior PE or deep vein thrombosis [DVT], preinjury anticoagulation, OTA fracture type, ISS); triggers for obtaining a test for the diagnosis of PE (vitals, electrocardiogram [EKG]/arterial blood gas [ABG], Wells score, presence of symptoms); type and findings of the diagnostic test (CTPA, ventilation-perfusion [V/Q scan], size and location of PE, presence of DVT); PE treatment (type of anticoagulation, peak international normalized ratio [INR]/partial thromboplastin time [PTT], inferior vena cava [IVC] filter); treatment complications (bleeding, death, return to operating room (OR), change in anticoagulation); and outcomes (improvement in vitals or symptoms, death, repeat PE or DVT).

**Results:** There were 312 patients, 186 men and 126 women, with a mean age of 58 years (range, 15-101). Average BMI was 29.6, and mean ISS was 18 (range, 4-66). 17% received anticoagulation prior to injury (primarily aspirin), and 5% had a prior history of PE. After injury, 87% were placed on prophylactic anticoagulation, 69% with low molecular weight heparin. 53% of patients exhibited shortness of breath or chest pain. Average heart rate and

O<sub>2</sub> saturation prior to PE diagnosis were 110 and 94, respectively. 39% had abnormal ABG and 30% had abnormal EKG findings. 89% had CTPA for diagnosis. Most clots were segmental (61%), followed by subsegmental (22%), lobar (9%), and central (8%). Most patients were treated with unfractionated heparin (UFH) and warfarin (25%), and 54% of those receiving UFH were bolused. Initial bolus did not correlate with bleeding. Complications of anticoagulation were common: 12% had bleeding at the surgical site and 17% were returned to the OR; 12% experienced bleeding at another site. Other complications included gastrointestinal bleed (5), anemia (5), wound complications (3), death (3), and compartment syndrome (2). With regard to outcomes, PE recurred in 2%, and 6% died of PE within 6 months.

**Table 1.**

Bleeding complications by clot size from smallest (subsegmental) to largest (central).

PE Type	Subsegmental	Segmental	Lobar	Central
Bleeding—surgical site	10%	11%	19%	17%
Return to OR	0%	1%	10%	6%
Bleeding—other site	6%	14%	14%	22%
Death (anticoagulation)	2%	1%	0%	6%
PE recurrence	0%	0%	5%	0%
Death from PE	0%	2%	5%	17%

**Discussion:** This is the first large data set to evaluate the course and complications of PE in an orthopaedic trauma population. The treatment for smaller, less-concerning clots (subsegmental and segmental) was the same as for central clots. The complications of anticoagulation are significant and were as common in the patients with lower risk clots as those with higher risk clots. Very low risk clots (subsegmental) comprised 22% and lower risk clots (segmental) 61% of those seen, as opposed to central clots (8%) which have a high mortality risk. This is just an initial snapshot of where we are in terms of management of PEs in trauma patients, but reveals a high complication rate for anticoagulation, including death. We may wish to modify treatment algorithms based on the risk and size of the clot rather than treat all clots equally. Further work is needed to define these competing risks and benefits prospectively.

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**BSFF SYMPOSIUM 3:  
ATYPICAL FEMUR FRACTURES**

**Moderators:** *Joseph Borrelli, Jr., MD*  
*Saam Morshed, MD, PhD*

- 12:45 pm **Did Experimental Evidence Tell Us of the Problems with Long Term Bisphosphonate Use?**  
*Joseph M. Lane, MD*
- 12:55 pm **Making the Observation: From the First Cluster of Events to Quantifying the Risk**  
*Saam Morshed, MD, PhD*
- 1:05 pm **When are Large Trials not Large Enough to Give Us Answers?**  
*Brad A. Petrisor, MD*
- 1:15 pm **Lessons Learned: How Do We Avoid This Type of Problem from Happening Again?**  
*Susan V. Bukata, MD*
- 1:25 pm **Bisphosphonate-Related Femur Fractures: Outcomes of Operative and Nonoperative Management**  
*Kenneth A. Egol, MD*
- 1:35 pm Discussion

NOTES

## Inhibiting Macrophage Activation During Fracture Repair Improves Fracture Healing in Aged Mice

*Yan Yiu Yu, PhD; Theodore Miclau III, MD; Ralph S. Marcucio, PhD;  
Department of Orthopaedic Surgery, Orthopaedic Trauma Institute,  
University of California San Francisco, San Francisco, California, USA*

**Purpose:** Inflammation plays a critical role in fracture repair. This inflammatory response is tightly regulated, and persistent inflammation may impair healing. We hypothesized that proinflammatory macrophages may contribute to age-related impairments in fracture healing. Therefore, we inhibited macrophage activation by administering cFMS inhibitors, PLX3397, and assessed fracture healing in aged animals.

**Methods:** Closed, nonstabilized fractures were produced via three-point bending in the middiaphysis of the right tibia. Animals were fed either a PLX3397 or control diet beginning 2 days before fracture and throughout the healing process, and tissues were collected at day 5. Macrophages were detected by immunohistochemistry with F4/80 at 4°C overnight followed by biotinylated secondary antibody and the ABC reagent. Sections were developed with DAB (3-3'diaminobenzidine), and the number of macrophages was determined. Next, 4-week and 18-month-old male mice were fed PLX3397 diet from day 1-10, day 1-5, and day 5-10 postfracture. All tissues were collected on day 10. Specimens were fixed and decalcified in paraffin embedded and sectioned. Sections were stained with modified Milligan's trichrome and callus (TV), cartilage (CV), and bone (BV) volumes, and the proportions of cartilage (CV/TV) and bone (BV/TV) were quantified via stereology.

**Results:** *PLX3397 reduced the number of macrophages at fracture site.* The total number and the density of macrophages per callus area at the fracture site were significantly reduced in PLX3397-treated animals at 5 days postfracture. *Effect of reduced macrophages during fracture healing in juvenile mice:* There were no significant differences in TV among all groups by 10 days postfracture. Total cartilage volume was significantly retained in animals receiving PLX3397 from day 5-10 compared to those without treatment and CV/TV was significantly increased in animals receiving PLX3397 from day 5-10 compared to other groups. BV and BV/TV were not significantly different among all groups. *Effect of reduced macrophages during fracture healing in aged mice:* There were no significant differences in TV among all groups by 10 days postfracture. Total cartilage volume was significantly increased in animals that received PLX3397 throughout the first 10 days of healing compared to those without treatment. Total bone volume was significantly increased in animals that received PLX3397 treatment from day 1-10 compared to animals treated from day 5-10 and those without treatment. BV/TV and CV/TV were not significantly different among all groups except CV/TV was significantly increased in animals that received PLX3397 from day 1 to day 5 compared to those without treatment.

**Conclusion:** We demonstrate that cFMS inhibitors effectively blocked macrophage recruitment to the fracture site by more than 80%. Our results also show that inhibiting macrophage activation throughout the healing process in aged animals increased bone formation. These data support our hypothesis that inhibiting macrophage activation during fracture repair may improve fracture healing in aged animals by more rapid resolution of inflammation.

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**Δ The Role of the Progressive Ankylosis Protein (Ank) in Bone Fracture Healing**

*Martin Quirno, MD; Scott R. Hadley, MD; Kenneth A. Egol, MD; Thorsten Kirsch, PhD; NYU Hospital for Joint Diseases, New York, New York, USA*

**Purpose:** Bone fracture healing follows a well-orchestrated cascade of cellular events that when impaired results in significantly weaker bone or delayed union. We have shown that the progressive ankylosis protein (Ank) stimulates the osteoblastic differentiation of mesenchymal stem cells and lack of Ank leads to significant osteoporosis. Understanding the mechanisms of how Ank stimulates osteoblast differentiation and ultimately bone formation may lead to the development of novel treatments of diseases associated with bone loss, including osteoporosis, or strategies to improve bone healing after fractures. The purpose of our study was to compare the fracture healing process between ank/ank mice and wild type (WT) littermates following iatrogenic femur fractures.

**Methods:** We used a well-established femur fracture model in 20 6-week-old ank/ank mice and twenty WT littermates. Mice were followed with weekly radiographs and different groups were euthanized at 2 and 5 weeks after fracture. Bone fracture callus was analyzed radiographically on a weekly basis, histomorphometrically by quantifying Alcian blue and safranin O callus stainings, and by micro-CT for the calculation of callus properties such as volume, density, cortical thickness, as well as trabecular analysis. Biomechanical three-point load to failure was also used.

**Results:** Radiographically, the ank/ank mice showed a marked delay in callus formation compared to WT littermates. Micro-CT revealed a significant decrease in total volume and bone volume at 2-week follow-up. Micro-CT also revealed a significant decrease in bone density, average cortical thickness, as well as trabecular number, thickness, and spacing at both time points. These results were confirmed by histologic analysis demonstrating a marked reduction in callus area and density as well as the number of hypertrophic chondrocytes. Biomechanically ank/ank mice required significantly less load to induce failure compared to the WT littermates.

**Conclusion:** Ank plays an important role in both the callus and bone formation stages of endochondral fracture healing. This particular model mimics the effects of fracture healing in osteoporotic bone. Further understanding of the exact role of Ank in bone/cartilage formation may lead to the discovery of novel therapeutic strategies to improve fracture healing.

**Δ Role of HtrA1 in the Transition From Cartilage to Bone in Fracture Healing***Marie E. Walcott, MD; John J. Wixted, MD; Monica Thim, BA; David C. Ayers, MD;**Paul J. Fanning, PhD;**University of Massachusetts Medical School, Worcester, Massachusetts, USA*

**Background/Purpose:** Endochondral bone formation is fundamental to the process of normal fracture healing. Central to the process of endochondral ossification is the production and destruction of chondrocytes along with their associated extracellular matrices (ECMs). The effects of mechanical stability have been studied extensively in bone remodeling but are lacking in the study of cartilage tissue turnover in fracture healing. Interestingly, a serine protease HtrA1 (high-temperature requirement protein A1) with cartilage ECM-degrading activity and mechanoresponsiveness has recently been identified. HtrA1 expression is restricted to the pericellular matrix (PCM) that immediately surrounds the chondrocyte. Taken together, these data strongly suggest that an understanding of the role of HtrA1 and the chondrocyte PCM in fracture healing is needed. We hypothesized that HtrA1 expression levels would vary temporally and spatially during the progression of fracture healing in mice. Additionally, we have asked whether these levels differ between rigid versus flexible internal femur fracture fixation situations. Such differences could implicate relationships between chondrocytes, HtrA1 expression, PCM turnover, and the inception of delayed fracture healing.

**Methods:** *Fracture technique:* Reproducible transverse femur fractures were generated via a traumatic three-point bending method with reproducible energy of injury in 8-week-old C57B/6 male mice. *Quantitative real-time polymerase chain reaction (PCR):* On sacrifice days 6, 8, and 10 the fractured limb callus was dissected free and callus tissue alone was placed in TRIzol reagent. The tissue was ground using a Polytron homogenizer and total RNA isolated using a commercially available kit. Potential DNA contamination was removed by RNase-free DNase treatment. Reverse transcription reaction was performed using 1 $\mu$ g of total RNA and random hexamer primers. Relative transcript levels were measured by quantitative PCR (qPCR) in an ABI PRISM 7000 FAST sequence detection system and were normalized to GAPDH (glyceraldehyde-3-phosphate dehydrogenase) mRNA levels using commercially available primers and SYBR-Green master mix.

**Results:** HtrA1 mRNA levels were found to increase over the first 2 phases of fracture healing (inflammatory and cartilage formation) and peaked at day 14 during the transition period from peak cartilage formation to primary bone formation/ coupled resorption. qPCR revealed differences in gene expression events involved in chondrocyte pericellular matrix degradation between rigid versus flexible fractures. Flexible fixed fractures showed higher levels of mRNA for HtrA1 and discoid domain receptor 2 (DDR2) versus rigid fractures at day 7 of fracture healing. In addition, markers for early endochondral bone formation (vascular endothelial growth factor, collagen type II and collagen type X) were reduced in flexible femur fractures compared to rigid fractures.

**Conclusions:** In this study, we examined the effect of mechanical stability on chondrocyte behavior during the early stages of endochondral ossification in fractures. Our data vali-

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date a new methodology for studying the molecular mechanisms of mechanotransduction during fracture repair using relatively rigid or flexible fixation. In doing so, we are able to demonstrate an important role for the chondrocyte PCM in regulating the behavior of chondrocytes. These data provide insight into the potential role of both HtrA1 and DDR in regulating these early processes and suggest a potential role for pericellular chondrocyte signaling along the continuum of fracture healing from union to nonunion.



## Tracking the Homing of Mesenchymal Stem Cells and Efficacy of Their Healing Potential in a Mouse Fracture Model

Tina Dreger, MD<sup>1</sup>; J. Tracy Watson, MD<sup>1</sup>; Zijun Zhang, MD, PhD<sup>1</sup>; Walter Akers, DVM, PhD<sup>2</sup>;

<sup>1</sup>Saint Louis University School of Medicine, Saint Louis, Missouri, USA;

<sup>2</sup>Washington University School of Medicine, Saint Louis, Missouri, USA

**Background:** Myriad options are currently being evaluated for the treatment of bone loss and nonunions. Cellular therapies have great appeal and many specific cell populations continue to be investigated. Mesenchymal stem cells (MSC) are one of these populations essential for fracture healing. Previous studies have used MSC isolated through plastic adhesion, and expanded in culture. However, this led to phenotypic modification of the MSC. In vitro, these cells demonstrated osteogenesis, but in vivo fail to produce bone. Following fracture, tissue inflammation builds a chemokine gradient that attracts MSC to the fracture site. The ability to use phenotypically unmodified MSC to home to a fracture site when transplanted intravenously would be of great value in improving our understanding of MSC and how they would aid bone formation for clinical applications.

**Purpose:** The purpose of this study was to (1) demonstrate migration kinetics of injected MSC in a mouse fracture model homing to the fracture site using undifferentiated MSC; and (2) evaluate the viability of undifferentiated MSC obtained from medullary reamings, and demonstrate their fracture healing ability.

**Methods:** Intramedullary reamings were collected on all long bone intramedullary nailings at our institution under IRB approval. Undifferentiated MSC were isolated using the CD-271 marker and expanded in culture. Near-infrared fluorescence (NIF)-labeled MSC were suspended in a phosphate buffered saline (PBS) solution. A standardized femur fracture model was created in immunodeficient nude mice and labeled MSC were injected into the tail veins of study mice at various time post fracture: group 1, injected day 1; group 2, day 3; and group 3, day 7 post fracture. Control mice received only PBS injections post fracture. All mice underwent sequential near-infrared imaging of both femurs at 24 hours, 48 hours, and 7 days post injection. Mice were sacrificed at 3 weeks post injection and fractured femurs underwent histologic and radiographic analysis.

**Results:** When analyzed as a whole, significant migration of MSC was seen at 24 hours ( $P = 0.004$ ), and 7 days post injection ( $P = 0.013$ ). Individual groups were then analyzed at each time frame. Group 1 demonstrated significant MSC migration to the fracture site compared with its own control contralateral nonfractured femur that was maintained through all time points:  $P = 0.043$  at 24 and 48 hours, and  $P = 0.042$  at 7 days. For group 2 with injection 3 days post fracture, significant difference was found at 24 hours ( $P = 0.043$ ), but not at 48 hours or 7 days ( $P = 0.5$  and  $P = 0.225$ , respectively). No significant difference was found for group 3, injection 7 days after fracture ( $P = 0.18$  at 24 hours,  $P = 0.18$  at 48 hours). Histologic evaluation demonstrated increased callus formation, and improved fracture healing in all MSC injected study mice compared to the control group (no MSC). The most important variable appears to be the temporal relationship between fracture and injection of labeled MSC.

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**Conclusion:** This pilot study demonstrates the successful ability to expand a population of unmodified MSC from an exogenous source, and use these cells to augment fracture healing. Migration of MSC can be identified through NIF techniques and temporal relationships regarding injection time relative to injury appears to be the crucial factor in terms of augmenting fracture callus. These results provide valuable information into how future cellular therapies may be used for clinical applications in terms of timing of intervention.

### Notch Signaling in Mesenchymal Stem Cells (MSCs) Harvested from Geriatric Mice

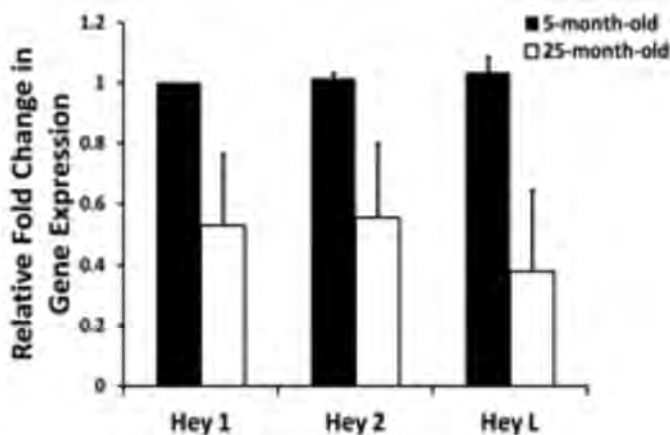
*Patricia L. Mutyaba, BS; Hailu Shitaye, PhD; Nicole S. Belkin, MD; Chancellor F. Gray, MD; Derek Dopkin, BS; Jaimo Ahn, MD, PhD; Kurt D. Hankenson, DVM, PhD; University of Pennsylvania, Philadelphia, Pennsylvania, USA*

**Purpose:** Morbidity associated with geriatric fractures may be attributed, in part, to compromised MSC function within the fracture callus and late onset of endochondral ossification. The Notch signaling pathway has been shown to be important for healing of nonskeletal tissues in an age-dependent manner. Our purpose is to inform clinical therapies for bone repair by studying Notch signaling in MSCs as a function of age in a murine model.

**Methods:** MSCs were harvested from 5- and 25-month-old C57BL/6 mice. Primary MSC cultures were analyzed for osteogenic and adipogenic potential. Notch signaling was measured at baseline and after induction with Jagged-1. MSCs were harvested from mouse femora, and maintained in standard media. At days 1 and 4 postplating, cell viability was assessed with Alamar blue. For osteogenesis, cells were maintained in 5 mM  $\beta$ -glycerol phosphate and 100  $\mu$ M L-ascorbate. Calcium deposits were analyzed with 2% Alizarin red S (ph 41-4.3). For adipogenic induction, cells were placed in media containing 57  $\mu$ M isobutyl-methylxanthine, 1  $\mu$ M dexamethasone, 1  $\mu$ g/mL insulin, and 5  $\mu$ g/mL troglitazone for 3 days and maintained in 1  $\mu$ g/mL insulin. Adipogenesis was evaluated with 0.5% Oil-Red-O staining, extraction, and spectrophotometry. For the Notch stimulation assay, Jagged1/Fc chimera (R&D Systems) was bound to Fc antibody-coated 6-well plates. Bulk marrow cells were plated on uncoated wells (TC), wells coated with Fc only, and wells coated with both Fc and the Jagged1/Fc chimera and then cultured for 4 days. For gene expression analysis, total RNA was harvested from cell cultures, reverse transcribed, and expression of Notch ligands, receptors, and target genes was determined quantitatively using real-time polymerase chain reaction with Power SYBR green.

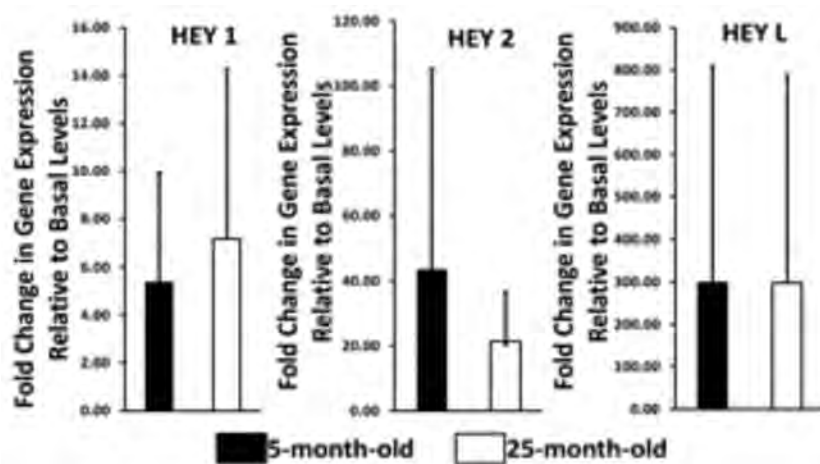
**Results:** MSCs from geriatric mice showed reduced rates of proliferation, adipogenesis, and variable rates of osteogenesis. Furthermore, MSCs from geriatric mice showed reduced basal expression of Notch targets, Hey 1, Hey L, and Hey 2 (Figure 1). Following plating on Jagged1, the fold change in gene expression of Hey 1, Hey L, and Hey 2 was elevated in MSCs from adult and geriatric mice without discernable differences between the two age groups (Figure 2).

**Figure 1** Notch target gene expression normalized to gene expression in 5-month-old. \* $P < 0.05$ .



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**Figure 2** Relative fold change in Notch target gene expression following plating on 1 ug/mL of Jagged1.



**Conclusion:** MSCs from geriatric mice exhibit reduced proliferation, adipogenesis, and inconsistent osteogenesis. Interestingly, they show decreased basal Notch activity, but are responsive to Jagged1. Therefore, therapeutic targeting of Notch signaling may be useful to improve geriatric fracture healing.

## **BMP-2 mRNA Expression After Endothelial Progenitor Cell Therapy for Fracture Healing**

**Ru Li, MD<sup>1,2</sup>; Aaron Nauth, MD<sup>1</sup>; Rajiv Gandhi, MD<sup>2</sup>; Khalid Syed, MD<sup>2</sup>;  
Emil H. Schemitsch, MD<sup>1</sup>;**

<sup>1</sup>*Dept. of Surgery, St. Michael's Hospital, University of Toronto, Toronto, Ontario, Canada;*

<sup>2</sup>*Dept. of Surgery, Toronto Western Hospital, University of Toronto, Toronto, Ontario Canada*

**Purpose:** Endothelial progenitor cells (EPCs) represent a population of novel precursor cells with known ability to participate in angiogenesis. Our previous studies have shown that local EPC therapy significantly increased angiogenesis and osteogenesis to promote fracture healing in an animal bone defect model. However, the cellular and molecular mechanisms by which EPC therapy promotes fracture healing remain largely unknown. The purpose of this study was to quantify local bone morphogenetic protein-2 (BMP-2) expression after EPC therapy for a rat segmental bone defect, in hopes of further defining the potential mechanisms by which EPCs promote fracture healing.

**Methods:** EPCs were isolated from the bone marrow of syngenic rats and cultured *ex vivo* for 7 to 10 days prior to transfer to the bone defect. A total of 56 rats were studied. The treatment group received  $1 \times 10^6$  EPCs locally at the bone defect and control animals received saline only. Animals were sacrificed at 1, 2, 3, and 10 weeks, and specimens from the fracture gap area were collected, pulverized, and total mRNA was extracted. BMP-2 mRNA was measured by reverse-transcriptase polymerase chain reaction (RT-PCR) and quantified by VisionWorksLS. All measurements were performed in triplicate.

**Results:** All EPC-treated bone defects healed radiographically by 10 weeks, whereas control-treated defects developed a nonunion. The expression of BMP-2 mRNA was significantly elevated in EPC-treated defects relative to controls at week 1 (EPC:  $0.59 \pm 0.10$ , control:  $0.31 \pm 0.08$ ,  $P = 0.05$ ), week 2 (EPC:  $0.40 \pm 0.06$ , control:  $0.23 \pm 0.04$ ,  $P = 0.04$ ), and week 3 (EPC:  $0.33 \pm 0.06$ , control:  $0.18 \pm 0.03$ ,  $P = 0.04$ ), but not at week 10 (EPC:  $0.31 \pm 0.06$ , control:  $0.21 \pm 0.04$ ,  $P = 0.15$ ). The highest mean expression of BMP-2 in EPC-treated defects was observed at 1 week, with a progressive decline in BMP-2 expression noted thereafter.

**Conclusion:** These findings demonstrate that EPC-treated bone defects demonstrate both radiographic healing and elevated expression of BMP-2 relative to control-treated defects. These results provide further insight into the potential mechanisms by which EPC therapy may promote fracture healing.

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### **Δ Cell Viability and Osteogenic Potential of Bone Graft Obtained via Iliac Crest Versus Reamer-Irrigator-Aspirator**

*Harmeeth S. Uppal, MD, MS; Blake E. Peterson, BS; Michael Misfeldt, PhD; David Volgas, MD; Yvonne M. Murtha, MD; Gregory J. Della Rocca, MD, PhD, FACS; Theodore J. Choma, MD; James P. Stannard, MD; **Brett D. Crist, MD, FACS**;*  
*University of Missouri, Columbia, Missouri, USA*

**Purpose:** This study was undertaken to compare cell viability and osteogenic potential between bone graft obtained from the iliac crest and using reamer-irrigator-aspirator (RIA).

**Methods:** Osseous samples were obtained from patients undergoing autogenous bone graft harvesting using either RIA (n = 25) (all femurs) or iliac crest bone graft (ICBG) (n = 21). Cell viability was assessed using trypan blue. Flow cytometry using cell surface markers CD 45, 34, 90, and 105 was used to identify the degree of differentiation of the cellular aspirate before and after culture. The tissue was cultured in basic growth media for 14 days and then introduced to inductive media for 14 days. Supernatant was taken at 3-day intervals starting at day 4 until day 28 when the cultured cells reached confluency. Osteocalcin production was measured in the supernatant using enzyme-linked immunosorbent assay (ELISA). Alizarin red staining for calcium deposition was performed after culture to further evaluate for osteogenesis.

**Results:** Both RIA and iliac crest tissue yielded cellular viabilities of at least 95%. Cell surface markers demonstrated growth of bone marrow-derived mesenchymal stem cells (MSCs) during tissue culture by staining positive to CD 90 and CD 105 and negative for CD 45 and CD 34. Differentiation toward osteogenic lineage was shown by production of osteocalcin, which significantly increased after induction in ICBG group by 508% and in the RIA group by 479%. Student *t* test demonstrated a significant increase in osteocalcin concentration between pre- and postculture within the iliac crest and RIA groups ( $P < 0.001$  for both). However, there was no significant difference between iliac crest and RIA groups ( $P = 0.7$ ). All samples stained positive for Alizarin red to signify calcium deposition within the matrix, which further shows differentiation toward osteogenic lineage.

**Conclusions:** Both RIA and ICBG harvesting yielded a high concentration of viable cells that differentiated into the osteogenic lineage, indicating that both methods are valid for obtaining autograft.

**BSFF SYMPOSIUM 4:  
INTRAOPERATIVE IMAGING**

**Moderators:** *Edward J Harvey, MD*  
*Amir M Matityahu, MD*

- 3:20 pm      **Digital Pre-Operative Planning: Is it Ready for Prime Time?**  
*Christian Krettek, MD*
- 3:30 pm      **Two D vs. 3D Computer Navigation:  
Does It Make the Technology More Appealing?**  
*David M. Kahler, MD*
- 3:40 pm      **Intraoperative Assessment of Reduction: Does It Make a Difference?**  
*Meir Marmor, MD*
- 3:50 pm      **Intraoperative Radiation Exposure: How Concerned Should We Be?**  
*Eric Meinberg, MD*
- 4:00 pm      **Intraoperative Imaging: What Is New on the Horizon?**  
*Chip Truwit, MD*
- 4:15 pm      Discussion

PAPER ABSTRACTS

NOTES

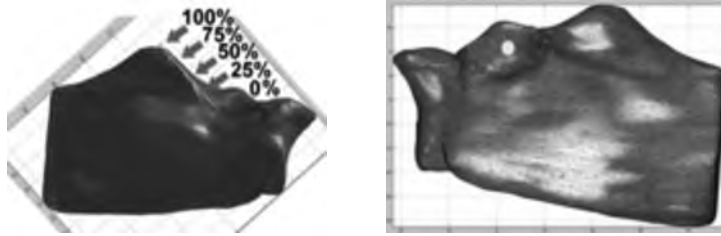
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### Δ Accurate Screw Placement for Displaced Intra-Articular Calcaneus Fractures

Jaron P. Sullivan, MD; Phinit Phisitkul, MD; J. Lawrence Marsh, MD; Jessica Goetz, PhD;  
University of Iowa Hospitals and Clinics, Iowa City, Iowa, USA

**Purpose/Hypothesis:** As the field of orthopaedic trauma surgery moves toward more limited approaches, the exact starting point and trajectory path for screws in displaced intra-articular calcaneus fractures is of increased importance. This study identifies a safe starting zone, screw length, and trajectory for screws to be placed from the posterolateral facet into the sustentaculum without violating the subtalar joint.

**Methods:** Eight intact cadaveric feet were CT-scanned at a resolution of  $0.2 \times 0.2 \times 1$  mm, and 3-dimensional reconstructions were created using Osirix software and MATLAB for simulating screw placement. At five locations (0%, 25%, 50%, 75%, and 100%) along the posterolateral facet joint as seen from the lateral CT 3-dimensional reconstruction, the perpendicular distance from the joint that provided safe passage (no violation of the subtalar joint) of a 3.5-mm screw to the goal location in the center of the sustentaculum was determined for all specimens. We also identified trajectory angles and the depth of the screws averaged over the eight specimens for each location.



**Results:** In order to not violate the subtalar joint and enter the center of the sustentaculum tali, screws must be inserted at least 5.8 mm (standard deviation [SD] 1.52; range, 4.2-7.9 mm) below the posterolateral facet joint line at the most anterior aspect, 5.1 mm (SD 1.72; range, 3-7.4 mm) at 25%, 5.5 mm (SD 2.22; range, 2.7-9) at 50%, 6.9 mm (SD 3.07; range, 1.5-12.2 mm) at 75%, and 8.3 mm (SD 3.97; range, 3.8-13.5) at the most posterior aspect of the joint (100%). Screw depth averages placed along the posterolateral facet at the border of the safe zone were as follows: 41.8 mm at 0% (SD 4.76), 40.2 mm at 25% (SD 4.04), 41.3 mm at 50% (SD 3.78), 42.4 mm at 75% (SD 3.89), and 43.2 mm at 100% (SD 4.55). When screws were placed at the border of the safe zone, the angle perpendicular to the plane of the joint on the lateral CT to enter the center of the sustentaculum was as follows: 8.8° at 0% (SD 2.61), 8.3° at 25% (SD 3.95), 7.9° at 50% (SD 4.40), 9.7° at 75% (SD 5.85), and 14.4° at 100% (SD 6.35).

**Conclusion:** As screws are placed more posterior along the posterolateral facet, there is greater variability in how far below the joint line a screw must start in order to remain extra-articular with a trend toward increasing distances. In order to remain extra-articular on all screws within our sample set, we recommend a start point of 9 mm below the anterior posterolateral facet, which tapers up to 1.7 cm along the posterior posterolateral facet to ensure that 95% (2 SD) of the screws are extra-articular. This study also gives guidance for trajectories of screws and screw depths.

Δ OTA Grant

See pages 97 - 144 for financial disclosure information.



## Shifting of the Forearm Bones With Improper Sizing in Radial Head Arthroplasty

Winston Elliott, MS<sup>1,2</sup>; Prasad Sawardeker, MD<sup>3</sup>; Check C. Kam, MD<sup>3</sup>;

Elizabeth A. Ouellette, MD, MBA<sup>1</sup>; Loren L. Latta, MD, PhD<sup>2,3</sup>;

<sup>1</sup>Miami International Hand Surgery Services, Miami Beach, Florida, USA;

<sup>2</sup>Max Biedermann Institute for Biomechanics, Miami Beach, Florida, USA;

<sup>3</sup>University of Miami, Department of Orthopaedics, Miami, Florida, USA

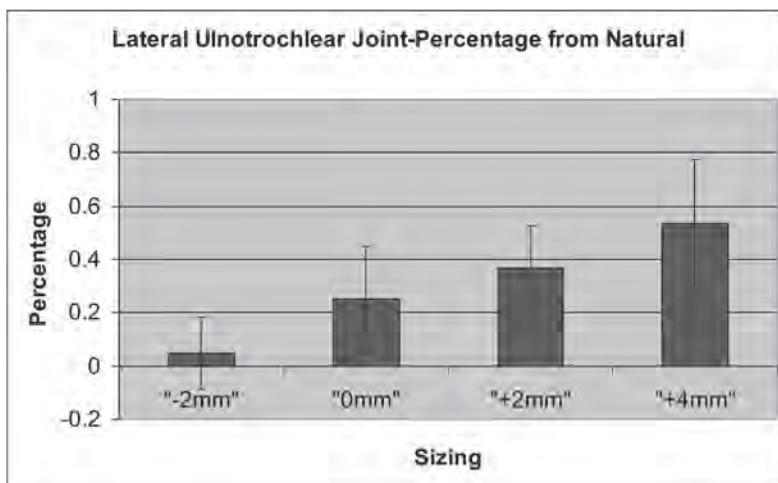
**Background/Purpose:** Radial head (RH) arthroplasty is a common response to comminuted RH fractures. Typical complications include improper sizing, leading to changes in joint kinematics. Evidence of these changes should be visible through fluoroscopic images of affected joints. The purpose of this study was to examine the ulnar deviation from distal radial translation (DRT), and the widening of the lateral ulnotrochlear joint space (LUT).

**Methods:** Eight fresh-frozen cadaver arms had initial images with the RH intact. The Kocher approach exposed the radiocapitellar (RC) joint capsule, preserving all ligaments. The RH was excised and a telescoping RH inserted. Images were taken with implant length: -2 mm, 0 mm, +2 mm, and +4 mm (from native) using 1-mm washers. AP fluoroscopic images of the elbow were taken at full extension. Joint spaces were measured using Image Pro software and calibrated from imaged markers. Four LUT measurements were made, two medially and two laterally. Each set was averaged together and the resulting value used for all comparisons. Images of distal ulnar deviation at the wrist were taken with the wrist in supination and the hand rotated medially. Measurements were from the distal medial radial tip to the distal lateral ulnar tip.

**Results:** DRT values were difference-paired for each arm using the 0-mm values as baselines. One-way analysis of variance (ANOVA) of the paired values did not show significant DRT with sizing increases ( $P = 0.109$ ). The quotient of DRT and sizing determined comparative impact with the LUT increase. LUT joint-gap measurements were percentage-paired, with natives as the baseline, and one-way ANOVA showed a significant increase in LUT spacing occurred with increased length ( $P < 0.01$ ) (see figure).

### Figure:

The percentage difference from native lateral ulnotrochlear joint space for different lengths. All values are above 0, indicating an increase in joint space for even under (-2 mm) and proper (0 mm) size.



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**Discussion:** Increased ulnar deviation can increase loading on the triangular fibrocartilage complex (TFCC), leading to possible TFCC tear, increased articular cartilage wear from carpal misalignment, and eventual wrist instability and arthritis. Oversizing results in small percentages of increased radial length at the wrist; therefore, deviation at the elbow must take place, either through rotation of the ulna or translation. Either of these can be seen through LUT measurements. Previous measurements of the LUT space showed similar results, but were made after ligament disruptions and repairs. This was being used as a method of improper sizing detection using plane radiographs. Increased LUT space can result in medial collateral ligament laxity, leading to increased osteophytes and arthritis, but has not been shown to be clinically disabling. Use and nontreatment can create a chronic, painful, disorder.

**Conclusion:** Increased LUT space indicates the medial translation of the proximal ulna.

## **Tibial Plateau Fracture Depression: Do Locking Plates Support the Entire Lateral Plateau?**

*Stephen A. Sems, MD; William W. Cross, MD; Joseph R. Cass, MD;*

*Department of Orthopedic Surgery, Mayo Clinic, Rochester, Minnesota, USA*

**Background/Purpose:** Depression of the posterolateral tibial plateau may occur as an isolated injury or as a part of a more complex pattern of injury. Precontoured tibial plateau locking plates allow multiple screws to be placed in a subchondral fashion to support the articular surface (rafting screws). Anatomic structures including the proximal tibiofibular articulation and lateral fibular collateral ligament limit placement of plates in the most posterior area of the lateral tibial plateau. Subsequently, the trajectory of the most posterior rafting screw is influenced by these limitations and may not provide optimal support to the posterior segment of the lateral articular surface. This study was undertaken to evaluate the ability of six commonly used proximal tibial plateau locking plates to allow rafting screw placement beneath the posterior articular surface of the lateral tibial plateau.

**Methods:** 6 different proximal tibial locking plates from 5 different manufacturers were applied to 30 Sawbones models of the proximal tibia (Pacific Research Laboratories). The six plates tested were the LISS (Synthes), 5.5-mm Periarticular Proximal Tibial Locking Plate (Zimmer), Polyax (DePuy), Peri-Loc (Smith & Nephew), 4.5-mm LCP Proximal Tibia Plate (Synthes), and Axsos (Stryker). The plates were applied in accordance with the manufacturer's recommendations by an experienced orthopaedic trauma surgeon. The trajectory of the posterior-most locking screw was identified and the area of the lateral tibial plateau articular surface anterior and posterior to this screw was calculated using a digital image analysis and processing program (Image J, National Institutes of Health).

**Results:** On average, 40% (range, 28%-55%) of the lateral articular surface of the tibial plateau was posterior to the most posterior screw in the proximal tibial plate. Average areas of the lateral plateau that were posterior to the rafting screws by plate type were: LISS (Synthes), 28%; 5.5-mm Periarticular Proximal Tibial Locking Plate (Zimmer), 34%; Axsos (Stryker), 36%; Peri-Loc (Smith & Nephew), 41%; 4.5-mm LCP Proximal Tibia Plate (Synthes), 43%; and Polyax (DePuy), 56%.

**Conclusions:** Common proximal tibial plateau locking plates fail to provide support to the posterior segment of the lateral tibial plateau. Fractures that exhibit posterolateral depression may benefit from additional or alternative techniques of fixation.

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**BSFF SYMPOSIUM 5:  
INSTITUTIONAL UPDATES: STATE OF MUSCULOSKELETAL RESEARCH**

**Moderators:** *Theodore Miclau, III, MD*  
*R Geoff Richards, PhD*

7:30 am **NIH/National Institutes of Arthritis, Musculoskeletal,  
and Skin Diseases Intramural Program**  
*Leon J. Nesti, MD*

7:45 am **AO Research Institute**  
*R. Geoff Richards, MD*

8:00 am **US Army Institute of Surgical Research**  
*Joseph C. Wenke, MD*

8:15 am Discussion

NOTES

## Electrospun Polyvinyl Alcohol (PVA)/Cyclodextrin/Tobramycin Nanofibrous Scaffold for Bone Infection

David C. Markel, MD<sup>1</sup>; Weiping Ren, MD, PhD<sup>1,2</sup>;

<sup>1</sup>Detroit Medical Center/Providence Hospital Orthopaedic Residency Program, Detroit, Michigan, USA;

<sup>2</sup>Department of Biomedical Engineering, Wayne State University, Detroit, Michigan, USA

**Purpose:** Osteomyelitis and bone nonunion are serious complications that arise due to combat-related open fracture injuries to the extremities. Development of biocompatible and biodegradable antibiotic delivery devices is highly desired to enhance the care of the survivors of traumatic extremity injuries. Electrospinning is one of the most promising methods to create 3-dimensional fibrous scaffolds with enormous surface area. We propose that the embedding of antibiotics in these 3-dimensional nanofibrous matrix will extend the drug release time. Tobramycin (TB) is an aminoglycoside antibiotic that is widely used in orthopaedic infections. Cyclodextrins (CD) are cyclic oligosaccharides that are frequently used as drug carriers. Polyvinyl alcohol (PVA) is biocompatible and has good fiber-forming capability. The purpose of this study is to develop and characterize the profile of electrospun PVA/CD/TB nanofibrous scaffold for extended and controllable TB release.

**Methods:** TB-embedded CD solution was prepared by mixing of TB solution (8 mg/mL) with CD solution (20 mg/mL) (1/1, v/v). The TB-CD solution was then added to PVA solution (13%, w/v) at a ratio of 1/2 (v/v). PVA/CD/TB nanofiber scaffolds were prepared using an electrospinning device. Morphology of electrospun nanofibers was visualized by light microscope, while nanofibers on calcium phosphate substrates were analyzed by scanning electron microscope (SEM). Bactericidal activity by PVA/CD/TB nanofibers was measured using a semiquantitative liquid bacterium culture medium inoculated with *Staphylococcus aureus* spore. Murine osteoblast precursor MC3T3 cells were cultured on the surface of cover slips with nanofibers for 1 week. Live/Dead staining was performed to determine cell viability.

**Results:** We found that the electrospun nanofibers were randomized aligned onto both the glass cover slips and on a calcium phosphate scaffold surfaces. The fiber densities of PVA, PVA-CD, and PVA-CD-TB nanofibers were similar. The diameter scale of nanofibers approximated to less than 1  $\mu$ m. PVA-CD-TB nanofibers showed certain conglutination. The bacteria growth was significantly inhibited by TB eluted from the PVA-CD-TB nanofibers. The eluant of PVA and PVA-CD has no inhibitory effect on bacterial growth. The PVA and PVA-CD nanofibers showed no cytotoxic effect, but TB-containing PVA-CD-TB nanofibers demonstrated some cytotoxic effects on MC3T3 cell line at a higher concentration given concentration (> 2 mg/mL).

**Conclusion:** The feasibility of preparation of drug-loaded nanofibers via electrospinning was proven in this study. The antibiotics released from nanofibers effectively inhibit the bacterial growth, which might provide a possible solution to orthopaedic infection. However, the dosage of TB incorporated in nanofibers needs to be optimized considering its potential cytotoxic impact. Electrospun nanofibers with excellent biocompatibility, biodegradability, and delivery of functional antibiotics would be a new and promising approach to treat bone infection.

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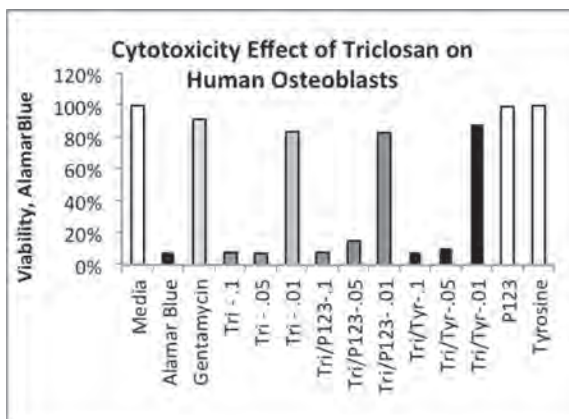
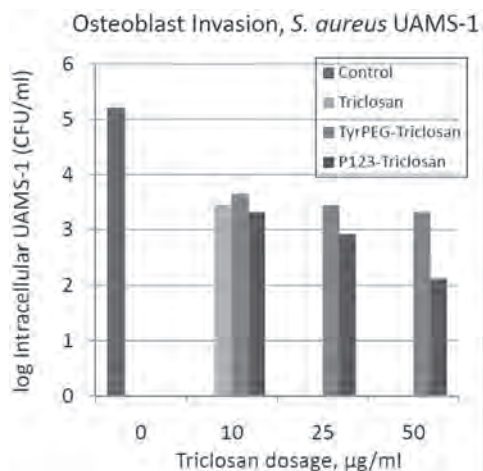
## Nanoparticle-Antimicrobial Complexes for the Treatment of Intracellular *Staphylococcus aureus* Osteoblast Infections

David I. Devore, PhD; Crystal Archer; Asa Vaughan; Maria Cormier; Krista L. Niece; US Army Institute of Surgical Research, Fort Sam Houston, Texas, USA

**Purpose:** Osteomyelitis is predominantly caused by *Staphylococcus aureus*, which has been shown to invade and persist in bone cells, thereby avoiding the host immune system and limiting the efficacy of antibiotic treatments. We hypothesized that polymeric nanoparticle complexes of the antimicrobial agent, triclosan, could effectively treat these intracellular osteoblast infections.

**Methods:** Nanoparticle complexes of triclosan were prepared by self-assembly in phosphate-buffered saline (PBS) using two biocompatible triblock copolymers: a triblock poly(alkylene oxide), Pluronic P123; and "TyrPEG" tyrosine-polyarylate-poly(ethylene glycol). Human osteoblasts were cultured in 12-well plates and infected with *S. aureus* UAMS-1, a clinical osteomyelitis isolate. Following drug treatment, osteoblasts were lysed and intracellular bacterial concentrations were determined by plating and counting colonies (CFU/mL). Cytotoxicity was determined by alamarBlue assays.

**Results:** The copolymer nanoparticles were able to bind high levels of triclosan such that its concentration in solution (PBS) was increased from 6  $\mu\text{g}/\text{mL}$  for free drug to over 2 mg/mL in the nanosphere solutions. The nanocomplexes reduced intracellular *S. aureus* by more than 99%. The copolymers themselves were not antimicrobial and not cytotoxic at the dosages required for treatment of the osteoblasts. Triclosan and its nanocomplexes were cytotoxic at 50  $\mu\text{g}/\text{mL}$ .



**Conclusions:** The P123 and TyrPEG nanoparticles effectively solubilized and delivered the hydrophobic triclosan at dosages sufficient to reduce or eliminate the intracellular *S. aureus* in primary human osteoblasts. While the copolymers were nontoxic at the required dosages, the cytotoxicity of triclosan to osteoblasts was significant at 50  $\mu\text{g}/\text{mL}$ . Hence the

potential of these nanocomplexes for clinical treatments of osteomyelitis depends on careful regulation of dosages.

**Disclaimer:** The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

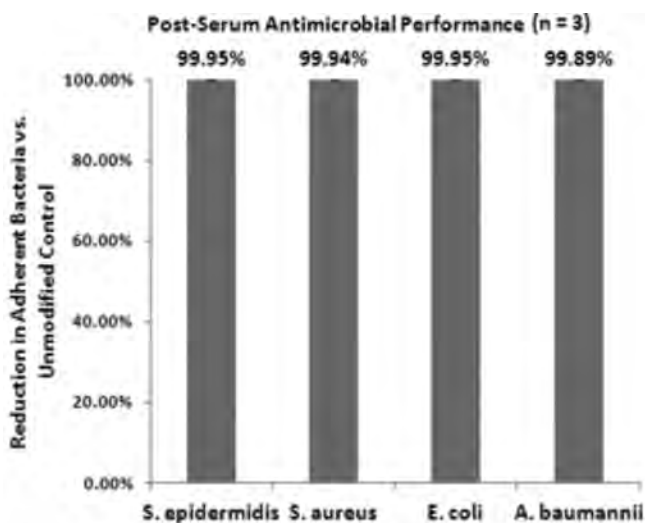
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### • Anti-Infection Trauma Devices With Drug-Releasing and Nonfouling Surface Modification

Hao Wang, MD; Karen D. Schultz, MD; Koby J. Elias, BS; Christopher Loose, PhD; Semprus BioSciences, Cambridge, Massachusetts, USA

**Purpose:** Trauma open fractures are often accompanied by initial infections from contamination and later deep infections with biofilm formation on implant surfaces. Polybetaine-modified surfaces have shown constant reduction in biofilm formation after 90 days in vitro exposure to blood serum. By coupling an antimicrobial release with a highly non-fouling betaine modification on titanium, this approach innovatively addresses the initial bacterial challenge and the longer term biofilm formation on orthopaedic trauma devices.

**Methods:** Titanium substrates were modified using proprietary technology to obtain a polymer reservoir for chlorhexidine (CHX) and a polybetaine surface layer. Characterization of the surfaces included: attenuated total reflectance infrared (ATR-IR) spectroscopy to verify the surface chemical composition, scanning electron microscopy (SEM), and laser confocal scanning microscopy (LCSM) to determine coating thickness and conformality, and a radio-labeled fibrinogen assay to quantify resistance to protein absorption. The in vitro drug release profiles were measured using ultraviolet-visible (UV-vis) spectroscopy and high-performance liquid chromatography (HPLC). A bacterial adherence assay method was used to determine the efficacy of modified samples to inhibit surface biofilm formation. The surface modification's bonding strength to the titanium substrate was measured and its resistance to abrasion was tested ex vivo by inserting the samples into the trabecular bone of porcine femur. Additionally, the biocompatibility of polybetaine was tested following ISO 10993 procedures.



**Results:** Titanium surfaces were successfully modified with a conformal and strongly bonded polymer layer. No scratches were observed when inserting the modified titanium wires into porcine femur and preservation of modification was confirmed by ATR-IR. Controlled release of CHX was demonstrated for more than 8 weeks and different formulations were tailored for different release rates. Greater than 3 log (99.9%) reductions in bacterial adherence were achieved following serum exposure for multiple gram-positive and gram-negative bacteria (figure). Additionally, the nonfouling properties were retained after several weeks of CHX release. Polybetaine-modified materials passed ISO 10993 testing for permanent implant devices.

See pages 97 - 144 for financial disclosure information.



**Conclusions:** The titanium surface modification coupling a cCHX release and a polybetaine layer has shown high efficiency and long-term efficacy against biofilm formation. These materials are mechanically robust and have demonstrated stability under physiologic conditions. The drug release profiles can be designed and tailored for specific applications with different infection control needs. By innovatively addressing the initial bacterial challenge as well as longer-term biofilm formation on trauma devices, this approach may be a superior solution to current biofilm control technology.

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## A Novel SCPP Scaffold Composite for Erythromycin Release in a Mouse Infection Model

David C. Markel, MD<sup>1</sup>; Nancy M. Jackson, PhD<sup>1</sup>; Jeffery C. Flynn, MD<sup>1</sup>; Weiping Ren, MD, PhD<sup>1,2</sup>;

<sup>1</sup>Department of Orthopaedics, Providence Hospital and Medical Centers, Southfield, Michigan, USA;

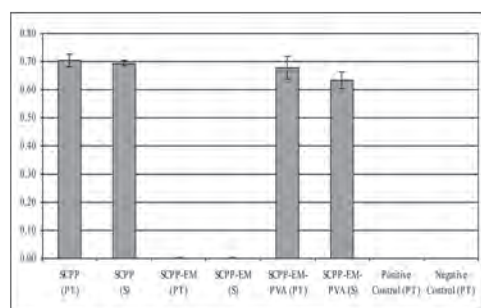
<sup>2</sup>Wayne State University Biomedical Engineering, Detroit, Michigan, USA

**Purpose:** We engineered strontium (Sr)-doped calcium polyphosphate (SCPP) scaffold. We found that SCPP with polyvinyl alcohol (PVA) coating extended the impregnated erythromycin (EM) release. The purpose of this study is to investigate whether EM-SCPP scaffold with a PVA coating has sustained bacterial inhibition in a mouse pouch infection model.

**Methods:** SCPP scaffolds (5 × 3 mm) were uploaded with EM by dip-soaking method (final 5%, w/w). SCPP-EM-PVA composites were prepared by soaking in a 7% PVA solution, followed by three freezing/thaw cycles (cross-linking). Pouches were created on the back of BALB/c mice by injection of air. Scaffolds were inserted into the pouch, followed by inoculation of 1 × 10<sup>3</sup> CFU of *Staphylococcus aureus*. Mice were sacrificed 14 days after surgery. Pouch tissues and scaffolds were collected, removed, and washed for microbiology and SEM analysis. The mice groups (n = 6 per group) are shown in the table below. Scanning electron microscopy (SEM) was used to evaluate bacterial growth on the scaffold. Washouts from pouch tissue and scaffolds were used for microbiology analysis (agar plate culture) and a quantitative bacterial growth assay, and the optical density (OD) of the broth at 600 nm was measured.

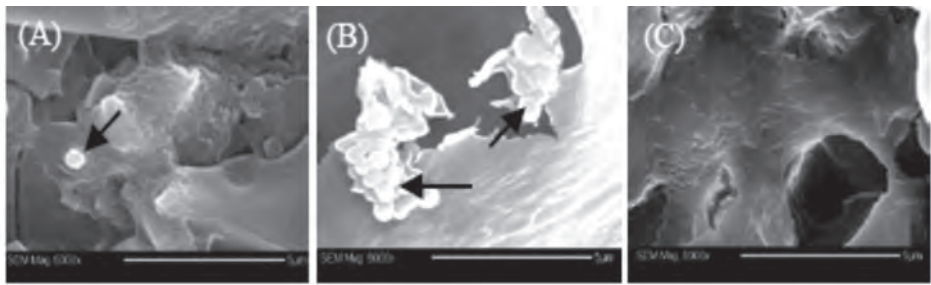
### Description of Mice Groups

1	Bacteria, SCPP
2	Bacteria, SCPP-EM
3	Bacteria, SCPP-EM-PVA
4	No bacteria, no scaffold
5	Bacteria, no scaffold



**Figure 1** OD of pouch tissue (PT) and scaffold (S) washouts after incubation

**Results:** As shown in Figure 1, in the absence of SCPP, the inoculated *S. aureus* was eliminated by the host mice immune surveillance. In the presence of SCPP, both the pouch tissue and scaffold were contaminated as evidenced by both agar plate testing and broth culture. SCPP-EM successfully inhibited bacterial growth, as compared to the SCPP group ( $P < 0.01$ ). However, SCPP-EM-PVA appeared to enhance bacterial growth, which was confirmed by SEM analysis (Figure 2), showing that bacterial growth on SCPP was rare, while in much larger numbers on the SCPP-EM-PVA composites.



**Figure 2** SEM: (A) Arrow pointing to single bacteria on SSCP scaffold; (B) Arrows pointing to clumps of bacteria on PVA coating of SSCP-EM-PVA scaffold; (C) No bacteria visible on SSCP scaffold.

**Discussion/Conclusions:** There are three interesting findings: (1) Balb/c mice are capable of eradicating low-grade *S. aureus* infection. SSCP scaffolds protect *S. aureus* from host immune surveillance. Thus, bactericidal scaffolds are required for the treatment of trauma-relevant infection. (2) SSCP-EM inhibits bacterial growth for up to 14 days, even if the EM was completely released from the scaffold within 2 days (based on our in vitro data). We propose that a sufficient inhibition of bacterial growth at the initial stage is critical. (3) PVA coating, intended to slow EM release, appeared to enhance infection. We propose that the swollen PVA gel matrix provides a temporary shelter for bacteria to grow. A much slower EM release through the PVA layer, leads to an insufficient concentration to eradicate bacterial invasion at the earlier stage. To combat this problem, EM should be embedded in the PVA coating simultaneously.

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**BSFF SYMPOSIUM 6:  
CYCLE OF INNOVATION**

**Moderators:** *Mohit Bhandari, MD, PhD, FRCSC*  
*Saam Morshed, MD, PhD*

- 9:35 am      **The Cycle of Innovation: Is There an Ideal Approach?**  
*Mohit Bhandari, MD, PhD, FRCSC*
- 9:45 am      **Taking Early Innovation into the Clinical Arena**  
*Paul Tornetta, III, MD*
- 9:55 am      **Taking Promising Innovation into Clinical Practice: What are the  
Studies We Should be Doing?**  
*Saam Morshed, MD, PhD*
- 10:10 am     **Getting through the FDA Approval Process**  
*Thomas A. Russell, MD*
- 10:25 am     Discussion

PAPER ABSTRACTS

NOTES

## Research in Orthopaedic Trauma: Has Anything Changed Since the Introduction of Levels of Evidence?

Brian P. Cunningham, MD<sup>1</sup>; Gilbert R. Ortega, MD, MPH<sup>2</sup>; Ryan McLemore, PhD<sup>1</sup>; Alexander C. McLaren, MD<sup>1</sup>;

<sup>1</sup>Banner Orthopaedic Residency, Phoenix, Arizona, USA;

<sup>2</sup>Sonoran Orthopaedic Trauma Surgeons, Scottsdale, Arizona, USA

**Background/Purpose:** Levels of evidence were introduced to orthopaedics in *The Journal of Bone and Joint Surgery* (JBJS) in 2003. The goal of introducing a systematic approach to study evaluation was to improve the quality of research in orthopaedics. A large amount of resources both at training programs and specialty meetings has been devoted to improving the quality of research carried out in orthopaedics. The effect of the introduction of levels of evidence on the quality of research in orthopaedic trauma literature has not been quantified. We present a quantitative analysis of the quality of research published in the *Journal of Orthopaedic Trauma* (JOT) from 2000 to 2010. We hypothesize that the quality of the orthopaedic trauma literature has improved since the introduction of levels of evidence.

**Methods:** JOT was reviewed at three time points: 2000, 2005, and 2010. Each year was evaluated and graded using the JBJS levels of evidence guidelines. Studies of animals, cadavers, basic-science articles, review articles, case reports, and expert opinions were excluded. Subsequently, the number of low (level 3 and 4) and high (level 1 and 2) quality articles published each year in JOT was compared based on categories developed by Tornetta et al. Changes from year to year were assessed using the Fisher exact test,  $\alpha < 0.05$ . The ability of residents to assign levels of evidence was validated. 13 residents and 13 attendings independently graded 20 blinded papers from JBJS (American Volume) 2009. Accuracy for residents was 76.9%, and not significantly different than attendings ( $\kappa = 0.75$ ).

**Results:** The overall volume of studies published was 40 in 2000, 41 in 2005, and 63 in 2010 (46.5% increase). Over the period studied in 2000, JOT had 7 high-quality (level 1 and 2) and 33 low quality (level 3 and 4) studies. In 2005 there were 4 high quality and 37 low-quality studies. This represented a nonsignificant drop in the proportion of high-quality studies ( $P = 0.349$ , Fisher exact test). From 2005 to 2010, the rate of publication changed from 4 of 37 to 4 of 59, representing a second, nonsignificant decrease in the proportion of high-quality studies ( $P = 0.709$ , Fisher exact test).

**Conclusion:** Despite significant resources devoted to improving the quality of research in orthopaedic trauma, our study shows that there has been no change in the amount of high-quality research being published since the publication of levels of evidence. The quality of orthopaedic trauma literature has not improved since the introduction of levels of evidence, while the volume of published studies has increased.

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## The Difficulty in Performing a High-Quality Randomized Trial for the Distal Radius: Are These Insurmountable Challenges?

*Paul Tornetta, III, MD; Tarek Sibai, MD; Hope Carlisle, RN;  
Boston University Medical Center, Boston, Massachusetts, USA*

**Background/Purpose:** It is clear that Level I trials of new technologies and techniques are needed to demonstrate real advantages as compared with established methods of treatment. To perform such a trial has many hurdles including creating clear indications and contraindications that may be applied generally, properly consenting patients, as well as patient factors and the ability to follow up. The purpose of this paper is to report some of the problems encountered in performing a strict randomized controlled trial.

**Methods:** Over a 4-year period, we evaluated all distal radius fractures for possible enrollment into a randomized trial of locked plating versus external fixation. We chose to use strict criteria for enrollment to avoid patients that would be well served with cast immobilization and enroll only those with clear operative indications. To be offered the study, the fracture radiographs needed to meet 3 of LaFontaine's 5 criteria or have a greater than 50% chance of loss of reduction based on the equation of McQueen. Additionally, patients had to speak English, agree to follow for 1 year, and meet several other criteria such as surgical equipoise. We screened all patients with a distal radius fracture and offered the study to all who met radiographic and other criteria. There was an observational arm for those who were willing to be followed, but refused randomization. Only the attending surgeon consented the patient with a clear explanation of each treatment arm and answered all questions. The principal investigator performed almost all of the consents.

**Results:** Over a 4-year period, we screened 568 patients with distal radius fractures. 300 of 568 (53%) met radiographic criteria based on Lafontaine or McQueen as described. Of these 300, only 39 (13%) were entered into the study. Of those, only 13 (33%) were willing to be randomized and 26 (67%) chose the management that they wanted, entering the observational arm. The reasons for patients who met radiographic criteria to be excluded from the study were: no English (103), refusal to follow for 1 year (47), surgeon's disbelief in equipoise (36), unable to fill out forms (24), choosing nonoperative management (23), volar fragment requiring fixation (23), open fracture (17), bilateral fracture (16), associated ipsilateral injury (10), prior injury (9), fracture >2 weeks old (9), refusal to consent (6), ulna diaphyseal fracture (5), patient lives out of state (4), prisoner (4), metastatic cancer (2). Note that all reasons were documented so the total is 338 for the 261 patients.

**Conclusion:** We attempted to perform a very stringent trial and were able to enroll only 13% of those who met eligibility by radiographic criteria. Most important is that with a carefully provided consent, two-thirds of the patients who agreed to enroll wanted to decide on their own treatment and were unwilling to be randomized, although they picked different treatments. This experience strengthens the need to develop other mechanisms to compare outcomes such as expert-based trials and leaves the question of why other populations of patients agree to be consented. The consent process itself may require revisiting.

## Journal Impact Factor: Does It Reflect the Impact of Clinical Research in Trauma and Orthopaedic Surgery?

*Preetham Kodumuri, MBBS, MRCS; Jonathan Holley; Benjamin Ollivere, MD, FRCS; Christopher G. Moran, MD, FRCS; Nottingham University Hospitals, Nottingham, United Kingdom*

**Purpose:** Impact factor is considered to be a reflection of the academic importance of a journal to the wider scientific community, and publication in high-impact journals is often used as a surrogate marker for excellence in research. Many countries now use this as one of the performance indicators for academic departments in universities. It is calculated as the average citations per citable paper for the preceding 2 years. Impact factors are taken for the journal as a whole and do not necessarily reflect subspecialty impact or longer-term clinical impact. Journals are ranked by an impact factor calculated by Thompson Scientific, a commercial company.

**Methods:** We designed a study to evaluate the impact factors of the top 13 impact journals in trauma and orthopaedics, looking at the contribution of different subspecialties, such as trauma or hand surgery, the relative distribution of clinical and basic science research, and also the longer-term impact (in terms of citations) of these publications. All 4773 articles published in the top 13 journals during the 2-year period 2007–2008 were reviewed and categorized by their type, subspecialty, and superspecialty. All citations indexed through Google Scholar were then reviewed to establish the citation rate per article at 2 years and 4 years post publication.

**Results:** The top five journals published a total of 1986 research papers over the 2-year period. Three papers (0.0015%) were on operative orthopaedic surgery and none were on trauma. The majority (n = 1084; 54.5%) were experimental basic science. The highest impact journal to publish a good proportion of clinical papers on trauma (45%) was *The American Journal of Sports Medicine*. Clinical papers on trauma made up 20.5% of publications in *The Journal of Bone and Joint Surgery* (American Volume) and 19.14% in the *The Journal of Bone and Joint Surgery* (British Volume). Not surprisingly, subspecialty journals, such as the *Journal of Orthopaedic Trauma* (68.5%) and *Injury* (74.8%) had the highest proportion of clinical papers in trauma but both have a very low impact factor (*Journal of Orthopaedic Trauma* = 1.429; *Injury* = 1.509). Review of the timing of citations led to some interesting results. Surgical papers had a much lower citation rate (2.18) at 2 years when compared to basic science or clinical medical papers (eg, rheumatology, osteoporosis) with an average of 4.68 citations. However, by 4 years the citation rates for were similar (26.57 for surgery, 30.35 for basic science/medical). This suggests that there is a longer time lag before clinical surgical research has an impact when compared with medical specialties or basic science. We hypothesize that this may reflect the longer time lag in setting up and recruiting to research in surgery.

**Conclusion:** This study suggests that high-impact journals do not reflect the impact of clinical research in surgery. There may be a longer time delay before surgical papers are

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cited and so the 2-year citation rate, from which impact factors are calculated, may not be an accurate method for assessing the impact and performance of academic research in surgery.

See pages 97 - 144 for financial disclosure information.





ORTHOPAEDIC  
— TRAUMA —  
ASSOCIATION

# 28th Annual Meeting

## ANNUAL MEETING BEGINS

October 3 – 6, 2012

Minneapolis Convention Center  
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**SYMPOSIUM I:  
IMPROVING HIP FRACTURE CARE**

**Moderator:** *Prof. Christopher G. Moran, MD*

**Faculty:** *Stephen L. Kates, MD*  
*Kjell Matre, MD*  
*Keith M. Willett, MD*  
*Lau Tak Wing, MD*

- 1:20 pm      **Introduction**  
*Prof. Christopher G. Moran, MD*
- 1:25 pm      **Worldwide Epidemiology of Hip Fractures**  
*Lau Tak Wing, MD, Hong Kong*
- 1:40 pm      **The UK Hip Fracture Database: Results from the First  
200,000 Patients**  
*Prof. Christopher G. Moran, MD, Nottingham, England*
- 1:55 pm      **The Norwegian Hip Fracture Registry**  
*Kjell Matre, MD, Bergen, Norway*
- 2:10 pm      **Improving Standards of Care Through Audit and Financial  
Incentives: The Best Practice Tariff in England**  
*Prof. Keith M. Willett, MD, Oxford, England*
- 2:30 pm      **Improving Hip Fracture Care in the USA**  
*Stephen L. Kates, MD, Rochester, NY, USA*

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**More Reoperations After Intramedullary Nailing Compared With Sliding Hip Screws in the Treatment of AO/OTA Type A1 Trochanteric Fractures:****Results After 7643 Operations Reported to the Norwegian Hip Fracture Register***Kjell Matre, MD; Leif Ivar Havelin, MD, PhD; Jan Erik Gjertsen, Tarjei Vinje;**Birgitte Espehaug; Jonas M. Fevang, MD;**Orthopaedic Department, Haukeland University Hospital, Bergen, Norway*

**Purpose:** Sliding hip screws (SHS) and intramedullary (IM) nails are frequently used and well-documented implants for trochanteric fractures. There is no consensus as to which method is the best, and different treatment algorithms based on fracture type has been proposed. The aim of the present study was to compare the results for IM nailing and SHS in the treatment of AO/OTA type A1 trochanteric fractures using data from the Norwegian Hip Fracture Register (NHFR).

**Methods:** Data on 7643 primary operations for AO/OTA type A1 trochanteric fractures treated with either a SHS (n = 6355) or an IM nail (n = 1288) in the years 2005–2010 were collected from the NHFR. Patients' baseline characteristics and details from primary operations and reoperations were recorded by the surgeons. Questionnaires about pain and quality of life (EQ-5D) were answered by the patients 4, 12, and 36 months postoperatively. Reoperation percentages at 1 and 3 years were estimated using the Kaplan-Meier method and the Cox regression model was used to assess any influence of age, gender, comorbidity (American Society of Anesthesiologists [ASA] class), cognitive impairment, and implant on reoperation rates.

**Results:** Overall, 249 reoperations were identified, 189 (3.0%) within the SHS group and 60 (4.7%) within the IM nail group. In the survival analyses 1-year reoperation percentages were 2.4% and 4.2% for SHS and IM nails, respectively. The difference between the implants persisted over time, and at 3 years reoperation percentages were 4.5% for SHS and 7.1% for IM nails. In the Cox regression analyses, higher age and cognitive impairment reduced the risk of reoperation, whereas gender and ASA-class had no significant influence on the reoperation rate. The adjusted relative risk of reoperation for patients operated with an IM nail compared to a SHS was 1.61 (95% confidence interval [CI], 1.19–2.17;  $P = 0.002$ ). For pain and quality of life (EQ-5D<sub>index</sub> score), no statistically significant differences between the treatment groups were found during 3 years of follow-up. However, the rating of the two dimensions "mobility" and "usual activities" in the EQ-5D questionnaire were statistically significant in favor of IM nailing 1 year postoperatively.

**Conclusion:** We found more reoperations after IM compared to SHS in the treatment of the simple two-part trochanteric fractures 1 and 3 years postoperatively. A temporary and slightly better rating of the mobility for the IM nail group 1 year postoperatively cannot compensate for this. No difference of clinical relevance was found for pain or overall quality of life at any time during follow-up. Accordingly, despite modern trends suggesting otherwise, the SHS seems to be the best treatment for the simple two-part trochanteric fractures.

## **A Comparison of Cemented and Uncemented Bipolar Hemiarthroplasty Complications in the Early Postoperative Period**

*Ross K. Leighton, MD, FRCSC, FACS<sup>1,2</sup>; Uwe Dahn, MD<sup>1</sup>; Kelly Trask, BEng, MSc, CCRP<sup>2</sup>;*

*<sup>1</sup>Dalhousie University, Halifax, Nova Scotia, Canada;*

*<sup>2</sup>Capital District Health Authority, Halifax, Nova Scotia, Canada*

**Background/Purpose:** While the adverse effects of cement have been well delineated in the literature, cemented bipolar hemiarthroplasties have remained a mainstay of treatment for intracapsular hip fractures. The purposes of this study were: (1) to delineate any complications that occurred in the peri- or postoperative periods, and to determine whether or not these were associated with the use of cement and/or with patient specific factors; (2) to determine whether cementless implants were associated with higher rates of revision.

**Methods:** All consecutive bipolar hemiarthroplasties from 2001 to the present were retrospectively reviewed. Patient age and gender were recorded, along with surgery date, surgeon, length of stay on the orthopaedic service, and length of stay in hospital overall. Complications occurring in the perioperative period and in the first 48 hours postoperatively were also noted. Finally, any revisions to date of the initial bipolar implants were recorded.

**Results:** 700 bipolar hemiarthroplasties were performed, 383 (54.7%) cemented and 317 (45.3%) uncemented. Average age of patients was 80.2 years and there was no difference between groups. Females comprised 75.7% of all surgeries and there was no difference between cemented and uncemented groups. There was no difference in the death rate (7.29%) perioperatively, within hospital, or postdischarge (within 6 months). There were significantly more complications in the cemented group ( $P = 0.015$ ), while the uncemented group was slower to mobilize postoperatively ( $P = 0.0001$ ). Postoperative delirium and low oxygen saturation were also more prevalent complications in the cemented group ( $P < 0.002$ ). There was no significant difference in revision rate between the cemented (2.6%) and uncemented (1.9%) groups.

**Conclusion:** Overall there was no significant difference in death rate and revision rate between the cemented and uncemented groups. We found that adverse effects in patients were significantly associated with patient age and use of cement, while the uncemented group was slower to mobilize postoperatively.

We thus conclude that, especially in the frail elderly, the uncemented bipolar hemiarthroplasty represents a valuable alternative to the cemented bipolar hemiarthroplasty.

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**Internal Fixation Versus Cemented Unipolar Hemiarthroplasty for Displaced Femoral Neck Fractures in Elderly Patients With Severe Cognitive Dysfunction: A Randomized, Controlled Trial**

*Carl-Johan Hedbeck, MD; Christian Inngul; Richard Blomfeldt, MD; Hans Törnkvist, MD, PhD; Sari Ponzer, MD, PhD; Anders G. Enocson, MD, PhD; Karolinska Institutet, Department of Clinical Science and Education, Orthopaedic Unit, Stockholm Söder Hospital, Stockholm, Sweden*

**Background/Purpose:** Hemiarthroplasty (HA) is a well-established method for treatment of displaced femoral neck fractures in elderly patients. However, most surgeons have concerns about arthroplasty in patients with severe cognitive dysfunction due to the risk for complications such as dislocations and periprosthetic fractures. The aim of this study was to compare the outcome of internal fixation (IF) versus a cemented HA in femoral neck fracture patients with severe cognitive dysfunction.

**Methods:** 59 patients with a displaced femoral neck fracture were randomized to IF using 2 cannulated screws ( $n = 30$ ) or a cemented Exeter HA ( $n = 29$ ). All patients had severe cognitive dysfunction, but were able to walk independently before the fracture. They were reviewed at 4, 12, and 24 months after the fracture. Outcome assessments included complications, reoperations, hip function (Charnley score), and health-related quality of life (EQ-5D<sub>index</sub> score).

**Results:** A total of eight patients were reoperated (14%). Seven were in the IF group: non-union ( $n = 4$ ), trochanteric refracture ( $n = 2$ ), and lateral pain from protruding screws ( $n = 1$ ). One patient in the HA group was reoperated due to prosthetic dislocation. The EQ-5D<sub>index</sub> score at the follow-ups were generally lower in the IF group compared to the HA group. At 12 months the difference was significant ( $P = 0.03$ ); although consistent, due to the high mortality (63%), the difference was not significant at the 24-month follow-up.

**Conclusion:** HA seems to provide a safe option with better health-related quality of life compared with IF for these patients.

**Treatment of Pertrochanteric Fractures (AO/OTA 31-A1 and A2):  
Long Versus Short Cephalomedullary Nailing**

*Kaan S. Irgit, MD; Zhiyong Hou, MD; Thomas R. Bowen, MD; Michelle E. Matzko, PhD; Cassandra M. Andreychik, BA; Daniel S. Horwitz, MD; Wade R. Smith, MD; Geisinger Medical Center, Department of Orthopaedic Surgery, Danville, Pennsylvania USA*

**Background/Hypothesis:** We hypothesized that there is no clinical difference in outcomes between elderly patients with low-energy, simple, or multifragmentary pertrochanteric femur fractures without subtrochanteric extension (AO/OTA 31-A1 and A2) treated with a long versus short cephalomedullary nail.

**Methods:** The records of 409 patients presenting to a Level I trauma center between 2004 and 2009 with pertrochanteric fractures without subtrochanteric extension (AO/OTA 31-A1 and A2) were retrospectively reviewed. Patients treated with implants other than either a long or short cephalomedullary nail were excluded from the study. Patient demographics, treatment-related variables, and clinical and radiographic outcomes were recorded for each patient.  $\chi^2$ , analysis of variance, or nonparametric tests were used to compare patients treated with either a short or long cephalomedullary nail.

**Results:** 283 patients qualified for inclusion in this study (average age, 79 years [range, 53-102]); 100 patients were treated with a short nail (170 mm) and 183 with a long nail. All patients were treated with a single nail design having identical proximal fixation. The choice of long versus short nail was based on surgeon preferences. Excluding those who died in the perioperative period, the average postoperative follow-up was  $37 \pm 2.3$  months (range, 12-58 months). There was no significant difference in postoperative mortality rates between the two groups. There was no clinically significant difference in outcomes between patients treated with long nails compared to those treated with short nails. Patients treated with short nails had, on average, shorter operative times (41 vs 61 minutes,  $P < 0.0001$ ) and decreased blood loss (100 mL vs 135 mL,  $P = 0.031$ ). Implant-related complications and number of reoperations did not differ between groups. No postoperative fractures occurred distal to the short nail. There were two late, postoperative fractures occurring in two patients at the distal end of long nails.

**Conclusion:** Long nails offer no clinical advantage compared to short nails. The increased cost of the long nail (~\$500 more) and the greater operative time compared to short nails may not justify the use of a long nail in the treatment of simple and multifragmentary pertrochanteric femur fractures (AO/OTA 31-A1 and A2) in the elderly. Long nails do not appear to prevent fractures distal to the implant.

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**Short Versus Long Intramedullary Nails for Intertrochanteric Femur Fractures***Kelly Carlberg, MD; Christopher Boone, MD; Denise Koueiter, MS; Kevin Baker, PhD;**Jason Sadowski, MD; Patrick Wiater, MD; Gregory Nowinski, MD; Kevin Grant, MD;**Department of Orthopaedic Surgery, Beaumont Health System, Royal Oak, Michigan, USA*

**Purpose:** The use of intramedullary (IM) nails for intertrochanteric (IT) femur fractures has become a well-accepted and common procedure among orthopaedic surgeons. The patient population is typically older with several medical comorbidities and fixation can lead to difficult complications such as periprosthetic fracture (PPF). While short IM nails (SIMN) have been historically more common, surgeons at our institution have trended towards the use of long IM nails (LIMN) that extend to the distal metaphysis. The rationale for this is that IT fractures in the elderly are often the result of osteopenia/osteoporosis, a metabolic bone disease, and therefore these fractures can be considered pathologic. The standard of care for pathologic long-bone fractures is to protect the entire bone with the use of long IM implants. However, the use of longer nails may increase operative time and estimated blood loss (EBL), leading to more systemic complications. The purpose of this study was to compare EBL and operative times associated with long versus short IM nails for IT fracture fixation, as well as refracture rate around the site of the nail.

**Methods:** A retrospective analysis was conducted of IT fractures treated with IM nails from one manufacturer at our Level I trauma center between January 2001 and December 2011 by four fellowship-trained orthopaedic traumatologists. Only extra-articular fractures in the trochanteric area of AO classification 31A were included. Mechanism of injury was limited to low-energy injuries, including a fall or twist. Exclusions were minors, patients who sustained another lower extremity fracture at initial presentation, and patients with a diagnosed metabolic bone disorder other than osteoporosis. Medical records were reviewed for age, gender, EBL, operative time, length of stay (LOS), and PPF. Data were statistically analyzed by comparing these variables between long and short IM nails using a Mann-Whitney rank sum test, with statistical significance at  $P < 0.05$ .

**Results:** 225 qualifying patients (60 males, 165 females) were reviewed, with 1 bilateral IM treatment, for a total of 226 nails, of which 86 were SIMN and 140 nails were LIMN. Average age was  $82.1 \pm 9.6$  years (range, 45-101). The average EBL for LIMN ( $135.7 \pm 92.1$  mL) was found to be significantly greater ( $P = 0.002$ ) than EBL for SIMN ( $99.1 \pm 69.5$  mL). Average operative time was also found to be significantly greater ( $P = 0.001$ ) for LIMN procedures ( $64.4 \pm 25.4$  minutes) than SIMN procedures ( $44.3 \pm 13.4$  minutes). The overall incidence of refracture was 0.013% (3 total, 1 with SIMN and 2 with LIMN). EBL and operative time did not significantly vary as a function of surgeon, gender, or side.

**Conclusion:** The EBL and operative times were significantly lower for SIMN, indicating shorter nails could be a better option for patients with more severe medical comorbidities. The incidence of PPF was very low, and the LIMN did not reduce refracture rate. Other questions still remain, including the difference in morbidity with regard to revision surgery after PPF around short versus long implants.



**Locked Plating of Proximal Femur Fractures: Outcomes and Predictors of Failure**

**Robert A. Hymes, MD<sup>1</sup>; Kelly G. Kilcoyne, MD<sup>2</sup>; Tyler G. Marks, MD<sup>3</sup>; James S. Melvin, MD<sup>4</sup>; Scott Yang, MD<sup>5</sup>; Jennifer H. Wood, MD<sup>6</sup>; Matt L. Graves, MD<sup>3</sup>; David S. Weiss, MD<sup>5</sup>; Michael C. Tucker, MD<sup>6</sup>; Lisa K. Cannada, MD<sup>7</sup>; Elyse S. Brinkmann; J. Tracy Watson, MD<sup>7</sup>;**

<sup>1</sup>*Inova Fairfax Hospital, Fairfax, Virginia, USA;*

<sup>2</sup>*Walter Reed Medical Center, Bethesda, Maryland, USA;*

<sup>3</sup>*University of Mississippi, Jackson, Mississippi, USA;*

<sup>4</sup>*Carolinas Medical Center, Charlotte, North Carolina, USA;*

<sup>5</sup>*University of Virginia, Charlottesville, Virginia, USA;*

<sup>6</sup>*Palmetto Health, Columbia, South Carolina, USA;*

<sup>7</sup>*Saint Louis University, Saint Louis, Missouri*

**Background/Purpose:** Locked plate fixation for proximal femur fractures is associated with low union rates and frequently requires secondary procedures. Fractures of the proximal femur with associated comminution, instability, and/or wide displacement remain a challenge to orthopaedic surgeons. These fractures are increasingly being treated with proximal femoral locking plates (PFLPs). The purpose of this study was to evaluate the clinical outcomes of patients with proximal femur fractures treated with locking plates and to identify factors associated with failure.

**Methods:** A multicenter retrospective chart review was conducted over a 5-year time period (2005 to 2010). 60 patients treated with PFLPs for femoral neck and pertrochanteric fractures were identified. Data were extracted from the medical record and included demographic information, medical comorbidities, fracture characteristics, mechanism of injury, fixation construct, and quality of reduction. The patients were followed to determine fracture union and need for secondary procedures.

**Results:** Mean patient age was 46.2 years. Mean follow-up was 17 months. There were 33 males and 27 females. Most common mechanisms were low-energy falls (18), motor vehicle collisions (17), direct blunt trauma (7), and high-energy falls (6). Fracture patterns were 45 pertrochanteric (OTA 31-A), 12 femoral neck (OTA 31-B), and 3 combined. The rate of healed fractures in this study was 76.7%, and the rate of secondary procedures was 38.3%. The most common secondary procedure was revision internal fixation for nonunion (14). Six patients required additional surgery for hardware-related issues and five patients eventually underwent total hip arthroplasty. Univariate and multivariable logistic regression models were calculated to determine factors associated with healing. Transcervical (31-B2) fractures had the lowest healing rate (29%). All other fracture types had greater odds of healing compared to transcervical: peritrochanteric (31-A1 and 31-A2) had a healing rate of 60% (odds ratio [OR] = 8.0;  $P = 0.034$ ), intertrochanteric (31-A3) had a healing rate of 81% (OR = 27.5,  $P = 0.003$ ), and subcapital (31-B1 and 31-B3) had a healing rate of 75% (OR = 7.5,  $P = 0.085$ ). The use of standard screws distally was associated with an increase in healing rates (none = 44% healed vs 1-6 screws = 82% healed; OR = 5.8,  $P = 0.021$ ). Additional screws outside of the implant had an inverse relationship with healing (no screws = 81% healed vs screws = 42% healed; OR = 0.17,  $P = 0.038$ ). After adjusting for independent predictors in the model, intertrochanteric fractures were significantly more

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likely to heal compared to transcervical fractures (OR = 19.6,  $P = 0.02$ ), and longer implants (6 or more distal holes) were significantly associated with healing (OR = 9.7,  $P = 0.025$ ).

**Conclusions:** This study demonstrates that operative treatment with PFLPs has a high rate of failure and frequently requires a secondary procedure. Patients with intertrochanteric fractures had the highest healing rate whereas patients with transcervical fractures had the lowest healing rate. Other predictors of failure include shorter implants and increased numbers of locking screws distally.

**Displaced Femoral Neck Fractures in Patients <60 Years of Age**

*Stephen T. Gardner, MD; Michael J. Weaver, MD; Seth A. Jerabek, MD; Mark S. Vrahas, MD; Paul T. Appleton, MD; Mitchel B. Harris, MD; Brigham and Women's Hospital, Boston, Massachusetts, USA; Massachusetts General Hospital, Boston, Massachusetts, USA; Beth Israel Deaconess Hospital, Boston, Massachusetts, USA*

**Purpose:** Displaced femoral neck fractures in young patients are relatively rare and potentially devastating injuries. Primary arthroplasty is increasingly advocated for the older patient but is rarely indicated for patients <60 years of age. The two most common methods of fixation of these fractures are percutaneous cannulated lag screw (PCS) fixation and a sliding hip screw (SHS). This paper reports the outcomes of these two different fixation techniques in displaced femoral neck fractures in patients younger than 60 years of age.

**Methods:** A retrospective review of a prospectively enrolled trauma database was performed at three Level I trauma centers spanning the years 2000–2010. The electronic medical records and radiographs of all patients <60 years of age with displaced femoral neck fractures (OTA 31.B) treated by open or closed reduction and PCS fixation or SHS were individually reviewed. Quality of reduction was recorded for each fracture fixation construct and tip-apex distance (TAD) was recorded for each SHS construct. Exclusion criteria included all patients treated primarily with hip arthroplasty, follow-up <6 months, pathologic fracture through a bone lesion, or femoral neck fractures in association with acetabular or femoral head fractures. The primary outcome measurement was a return to the operating room within 6 months of the index procedure due to implant failure, or loss of reduction. Secondary outcomes were defined as loss of fixation after 6 months, symptomatic osteonecrosis requiring surgery, or nonunion requiring repair or conversion to total hip arthroplasty. A two-tailed Fisher exact test was used to compare independent outcome variables. *P* value was set at 0.05 to indicate statistical significance.

**Results:** 133 displaced femoral neck fractures were identified in 132 patients <60 years of age. 64 patients were excluded: primary arthroplasty (*n* = 41), follow-up <6 months (*n* = 17), pathologic fracture through a bone lesion (*n* = 3), and complex combined injury (*n* = 3). Our final study cohort was 69 femoral neck fractures in 68 patients. 40 patients were treated with SHS and 29 were treated by PCS fixation. Mean age in the groups was similar (SHS: 42.4 years, PCS: 43.7 years). Excluding patients with early failure, follow-up ranged 6 to 84 months (median, 18 months). TAD was <25 mm in 34 of 40 SHS patients. Reduction quality was graded as excellent (*n* = 19), good (*n* = 31), or fair (*n* = 8). 11 patients did not have immediate postoperative radiographs and quality of reduction could not be determined. At 6 months, only 1 (3%) patient in the SHS group lost fixation compared to 6 (21%) patients in the PCS group (*P* = 0.02). However, overall complication rates at most recent follow-up were similar between patients treated with SHS (25%) or PCS (31%) (*P* = 0.60).

**Conclusion:** There remains controversy regarding the optimal fixation method for displaced femoral neck fractures in younger patients. Biomechanical data suggest that SHSs are stronger than PCS constructs. It has been our clinical experience that fixation with SHS

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leads to a significantly lower short-term mechanical failure rate. The longer-term failure rate in our series is similar to other published reports and appears to be independent of fixation method. This suggests that biologic, and not mechanical, factors are most important in determining long-term outcome in these injuries.

**Outcomes After Treatment of Femoral Neck Fractures in Young Patients**

*Andrew N. Pollak, MD<sup>1</sup>; Emily Hui, MPH<sup>1</sup>; Renan C. Castillo, MS<sup>1</sup>; Bingfang Zeng, MD<sup>2</sup>; Dong Wang, MD<sup>2</sup>; Baotong Ma, DO<sup>2</sup>;*

*<sup>1</sup>R Adams Cowley Shock Trauma Center, Baltimore, Maryland, USA;*

*<sup>2</sup>The Shanghai Sixth People's Hospital, Shanghai Jiao Tong University, Shanghai, China*

**Purpose:** This study was undertaken to determine the contribution of clinical complications (osteonecrosis [ON], malunion, nonunion, and patient-reported pain) to outcomes after closed reduction and percutaneous screw fixation of displaced femoral neck fractures in young patients.

**Methods:** This prospective observational study was conducted at 3 high-volume Asian trauma centers. Of the 126 patients aged 18 to 55 years with eligible femoral neck fractures, 91 (72%) with complete 12-month follow-up were studied. Patients were followed according to standard of care for at least 12 months after injury to observe any clinical complications. Age, sex, initial injury fracture classifications (Pauwel and Garden), and baseline Short Form 36 (SF-36) general health questionnaire scores were recorded at time of enrollment. Follow-up data included radiographic evaluation for evidence of ON, nonunion and/or malunion, SF-36, and a visual analog scale (VAS) score for pain. SF-36 Physical and Mental Component Summary scores (PCS and MCS, respectively) were calculated.

**Results:** The mean age of the 91 patients with completed 12-month follow-up visits was 44.4 years (range, 20-55) and 48.4% were females. Analysis of clinical outcomes demonstrated 6.6% incidence of ON, 6.6% nonunion, 4.4% malunion, and 1.1% of patients with a VAS pain score >3. For the overall study group, mean PCS was 47 and mean MCS was 51.3. This compares to PCS population norms for this country ranging from 52 to 53.3, and MCS population norms ranging from 44.9 to 47.5. Clinical subgroup analysis indicated that patients with no observed complications had mean PCS and MCS scores of 48.4 and 51.1, respectively, while patients with any complications (12.1% of the patients) had mean PCS and MCS scores of 37.3 and 52.5, respectively. A multiple variable regression modeling approach was used to identify the contribution of each complication to outcome. None of the complications were significantly associated with lower MCS. Malunion was significantly associated with a 14.6-point reduction in the PCS ( $P = 0.002$ ). Nonunion showed a trend toward significant reduction in PCS by 6.6 points ( $P = 0.09$ ).

**Conclusion:** Femoral neck fractures in young patients are rare injuries. Traditional treatment recommendations include anatomic reduction and stable internal fixation to decrease the risk of complications. Most North American surgeons recommend an open approach to maximize the chance of achieving anatomic restoration of alignment and stable fixation. In other areas of the world, the simpler procedure of closed reduction and percutaneous screw fixation is more commonly employed with anecdotes indicating that good results can be achieved. Our preliminary study results demonstrate that complication rates overall were relatively low and outcomes good (SF-36 scores similar to population norms) with closed reduction. While patients with complications, particularly malunions, had significantly worse physical function outcomes, MCS scores were not different when comparing groups with and without complications. This is different than findings of many studies of mental function after trauma and may reflect better social support networks in the population studied.

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**Diagnosis of Femoral Neck Fractures Present With Femoral Shaft Fractures: Do We Need Intraoperative Radiographs?**

*Simon L. Amsdell, MD; Catherine A. Humphrey, MD; Jonathan M. Gross, MD; John P. Ketz, MD, John T. Gorczyca, MD; Holman Chan, MD; University of Rochester Medical Center, Rochester, New York, USA*

**Background/Purpose:** The association of occult femoral neck fractures with femoral shaft fractures is well established, and occurs in 1% to 9% of blunt femoral shaft fractures. The detection of femoral neck fractures can be missed in up to 50% of cases, which may have serious consequences. Previous studies have reported using protocols that include preoperative radiographs, fine-cut (2-mm spiral, or multislice) CT scans, and intraoperative radiographs to evaluate the femoral neck for fracture. Intraoperative radiographs can add significant anesthesia time and will increase radiation exposure. The purpose of this study was to evaluate the experience at a Level I trauma center using a protocol that includes intraoperative fluoroscopy, but not intraoperative radiographs, to rule out femoral neck fracture.

**Methods:** Billing records were reviewed for patients with femoral shaft fractures over a 10-year period. Patients who had an associated femoral neck fracture were examined in depth to determine the method and timing of diagnosis, patient specific variables, type of CT scan obtained, method of fixation, type of femoral neck fracture, and complication rates. Our protocol for detecting femoral neck fractures includes preoperative plain radiographs of the femur and pelvis, CT scan of the abdomen/pelvis obtained as part of trauma work-up (5-mm cuts were used for most of the study period), intraoperative fluoroscopy of the hip and femur, and postoperative radiographs.

**Results:** There were 1079 femoral shaft fractures identified over a 10-year time period. 29 patients (2.7%) had associated femoral neck fractures. 25 (86%) were identified preoperatively: 20 were visible on both plain radiographs and CT scan, and 5 were visible on CT scan alone. Two (7%) were identified intraoperatively with fluoroscopy (one before and one after insertion of the implant); in retrospect, both can be seen on preoperative CT scan. Two others (7%) were not identified until postoperative radiographs. In retrospect, both can be visualized on preoperative CT scans, although they were not detected at the time by the radiology or orthopaedic teams. Both remained nondisplaced and were stabilized with screw fixation in a second procedure. 19 of 29 femoral neck fractures (65%) were nondisplaced. All 29 femoral neck fractures were visible retrospectively on preoperative CT.

**Conclusions:** 2 of 29 femoral neck fractures (7%) were missed using our protocol, which compares favorably with the 20% to 50% rate reported in other studies. We do not believe that intraoperative plain radiographs are required. The two patients with femoral neck fractures identified intraoperatively by fluoroscopy also were visible on preoperative CT, but not preoperative radiographs. The two missed femoral neck fractures were visible on preoperative CT. This underscores the importance of careful evaluation of the CT of the femoral neck in every high-energy femoral shaft fracture. It remains uncertain if 2-mm-cut CT is required for detection, as most (79%) of the CT scans in our study had 5-mm cuts and all femoral neck fractures are visible retrospectively on CT scan.

See pages 97 - 144 for financial disclosure information.

**Delay to Surgery in Hip Fracture Patients: Effect on Mortality, Length of Stay, and Postoperative Morbidity***Reshid Berber, MBBS; Christopher G. Moran, MD, FRCS;**Queen's Medical Centre, Nottingham University Hospitals, Nottingham, United Kingdom*

**Purpose:** This study was undertaken to determine whether a delay to surgery (>36 hours) affects mortality rate, length of stay, and postoperative complications following hip fracture surgery in elderly patients.

**Methods:** Data were collected by dedicated audit staff using a pro forma designed in accordance with the "Standardised Audit of Hip Fractures in Europe" (SAHFE). This was a prospective observational study; all patients (n = 7207) who were admitted and underwent surgery during a 10-year period from May 1999 to May 2009 have been considered.  $\chi^2$  tests and independent-sample *t* tests were used for basic statistical analyses. Mortality data were analysed using Kaplan-Meier survival analysis and Cox regression analysis. *P* <0.05 was considered significant.

**Results:** The 30-day mortality was 9.5%. At 90 days, mortality was 18.9% and at 1 year it was 31.4%. In patients declared fit for surgery on admission (n = 5665), 30-day mortality was 7.5% in those operated on without delay, rising to 10.3% at over 4 days' delay (*P* = 0.117). However, for those operated on after 5-day delay, 30-day mortality equaled 13.6% (*P* = 0.009). Those declared fit for surgery on admission stayed a total 14.5 days if operated within 36 hours, rising to 16 days with over 36 hours' delay (*P* <0.001). An increase in the rate of urinary tract infection (3.9 vs 5.9%, *P* <0.001) was seen in patients delayed by over 36 hours. However, when considering all patients together, an increase in both urinary tract infection (3.9% vs 6.1%, *P* <0.001) and chest infections (7.9% vs 11.3%, *P* <0.001) was seen with over 36 hours' delay to surgery.

**Conclusions:** The 30-day mortality following hip fracture surgery is 9.5%. Patients admitted without comorbidities have significantly increased mortality when surgery is delayed by over 5 days. A 36-hour delay to surgery significantly increases length of stay. Urinary tract infection was the only postoperative morbidity to rise with delay to surgery in fit patients.

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**Postoperative Urinary Tract Infection Results in Higher Rates of Deep Infection in Patients With Proximal Femoral Fractures**

*Benjamin J. Ollivere, FRCS, MBBS, MD; Thomas Kurien, MBBS; Claire Morris, MA; Daren P. Forward, FRCS; Christopher G. Moran, MD, FRCS; Queens Medical Centre, Nottingham, United Kingdom*

**Purpose:** Patients presenting with a fractured neck of femur are a fragile group with multiple comorbidities who are at risk of postoperative complications. As many as 52% of patients are reported to suffer a urinary tract infection (UTI) after hip fracture surgery. As there are little data surrounding the effects of postoperative UTIs on mortality and deep prosthetic infection, we aim to investigate the effects of a perioperative UTI.

**Methods:** We prospectively investigated the impact of postoperative UTI in 9168 patients admitted to our institution with a diagnosis of proximal femoral fracture over an 11-year period in a prospective population study. We examined the effects of postoperative UTI on the incidence of deep infection, survivorship, and length of stay.

**Results:** Postoperative UTI occurred in 6.1% (n = 561) and deep infection in 0.89% (n = 82). Deep infection was significantly more common in patients complicated with a UTI (3.2% vs 0.74%,  $P < 0.001$ ) with a relative risk of 3.7:1. In 58% of patients the same organism was cultured in the urine and hip samples. A postoperative UTI did not adversely affect 90-day survival; however, it was associated with an increased length of stay (receiver operating curve [ROC] analysis, area under the curve [AUC] = 0.79). Delays to surgery and age were not predictive of a postoperative UTI.

**Conclusion:** Recognition of the risks posed by postoperative UTI and the risk factors for development of infection, and early treatment are essential to reduce the risks of increased subsequent periprosthetic infection.



### **No Effects of Blood Transfusion on Survival After Hip Fracture Surgery**

*S.J.M. Smeets, MD; Martijn Poeze, MD, PhD; Jan Verbruggen, MD, PhD;  
Maastricht University Medical Center, Maastricht, The Netherlands*

**Purpose:** Our primary goal was to audit the incidence of erythrocyte blood transfusion (EBT) after hip fracture surgery, to identify risk factors for blood transfusion, and study the effects on perioperative complications and survival.

**Methods:** In a retrospective cohort study, all patients 65 years old and above treated operatively for an acute hip fracture between 2003 and 2006 were included, with a 2-year follow-up period. We analyzed patient charts regarding patient and operation characteristics. Postoperative hemoglobin levels were used to investigate at what threshold EBT was used. The relation between EBT and perioperative complications and survival was analyzed with multivariate regression analysis. A propensity score for predicting the chance of receiving an EBT was calculated and used to differentiate between transfusion being a risk factor for mortality and other related confounding risk factors. Mortality was subdivided as in-hospital, 1-month mortality, 1-year mortality, and 2-year mortality.

**Results:** Of the 388 included patients, 41% received a blood transfusion. The postoperative hemoglobin level was the only significant predictor for EBT. Patients who received EBT had significantly more postoperative cardiac complications, even after adjustment for confounders. Multivariate analysis for mortality showed that EBT was a significant risk factor for early as well as late mortality, but after adding the propensity score, EBT was no longer associated with increased mortality.

**Conclusion:** EBT is associated with an increased frequency of cardiovascular complications after hip fracture surgery. There was no effect of EBT on mortality after correction with propensity scoring for predictors of EBT. This suggests that factors for transfusion are predictors for mortality itself.

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**PRESIDENT'S MESSAGE**  
*Robert A. Probe, MD*  
**"The Changing Value Proposition of the Orthopaedic Traumatologist"**

NOTES

**SKILLS LABS**

**Joint Spanning External Fixator for Temporizing Articular Fractures (#F1)**

Moderator: *Cory A. Collinge, MD*

Faculty: *Michael T. Archdeacon, MD; Bradley R. Merk, MD; Greg M. Osgood, MD; Robert A. Probe, MD; David Seligson, MD and Nirmal C. Tejwani, MD*

**ORIF Distal Femur Fractures (#F2)**

Moderator: *Mark C. Reilly, MD*

Faculty: *Derek J. Donegan, MD; David F. Hubbard, MD and Roger G. Wilber, MD*

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## CASE PRESENTATIONS

### **Coding Update with Case-Based Learning**

Moderator: *William R Creevy, MD*

Faculty: *J. Scott Broderick, MD and M. Bradford Henley, MD*

### **Pelvis and Acetabulum**

Moderator: *Paul Tornetta, III, MD*

Faculty: *Thomas F. Higgins, MD; Robert F. Ostrum, MD and Philip R. Wolinsky, MD*

### **Pediatric Femur Fractures**

Moderator: *Enes Kanlic, MD, PhD*

Faculty: *Amr A. Abdelgawad, MD; J. Eric Gordon, MD and Marc F. Swiontkowski, MD*

### **Proximal Humerus Fractures**

Moderator: *Utku Kandemir, MD*

Faculty: *Michael J. Gardner, MD; John T. Gorczyca, MD;  
Michael D. McKee, MD and Milan K. Sen, MD*

## NOTES

**SYMPOSIUM II:  
AUTOMOTIVE MEDICINE AND ORTHOPAEDIC TRAUMA**

**Moderator:** *James A. Goulet, MD*

**Faculty:**

**Add Symposium  
Breakdown?**

PAPER ABSTRACTS

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**MINI SYMPOSIA**

**Workers Compensation: An Orthopaedic Trauma Perspective**

Moderator: *Hassan R. Mir, MD*

Faculty: *Lisa K. Cannada, MD; Cory A. Collinge, MD; A. Alex Jahangir, MD  
William T. Obremskey, MD, MPH and Manish K. Sethi, MD*

**How to Establish and Run a Fragility Fracture Program  
(Own the Bone)**

Moderator: *James A. Goulet, MD*

Faculty: *Clifford B. Jones, MD; Kyle J. Jeray, MD and Marc F. Swiontkowski, MD*

NOTES

**Gravity Stress Radiographs: Does a Positive Radiograph Mean an Unstable Ankle?**

*Kate Ella Bugler; George Smith, FRCS; Timothy O. White, MD, FRCS;*

*Orthopaedic Trauma Unit, Royal Infirmary Edinburgh, Edinburgh, Scotland, United Kingdom*

**Background/Purpose:** Assessment of stability in ankle fractures is key in deciding the most appropriate mode of treatment. In supination–external rotation (SER) IV fractures where the medial stability is lost due to a ligamentous rather than a bony injury this assessment can be difficult. Stress radiographs have been suggested as a potential method for assessing the competence of the deep deltoid ligament and therefore ankle stability in patients with apparently isolated lateral malleolar fractures. Although stress radiographs have been found to be both sensitive and specific in cadaveric experiments, recent clinical studies have suggested that a widened medial clear space (MCS) on stress radiographs may not equate to a functionally unstable ankle. These previous studies have used manual stress radiographs and have included an operative arm in which patients were selected for surgical intervention based on empirical clinical criteria. We aimed to assess whether patients with an apparently isolated lateral malleolar fracture on presentation but with a positive gravity stress radiograph (GSR) could be successfully managed nonoperatively.

**Methods:** A prospective study of all patients with lateral malleolar fractures presenting to our orthopaedic trauma department was undertaken. Patients with an oblique distal fibular fracture pattern and no obvious MCS widening on routine radiographs underwent a GSR. Measurements of the radiographic MCS and superior clear space (SCS) were made and compared with published criteria; measurement of MCS alone is the most frequently described parameter, with values of 4, 5, and 6 mm variously suggested as cut-off points for diagnosing instability while some previous authors have recommended additional comparison of the MCS with the SCS.

**Results:** 67 patients underwent GSRs and were treated nonoperatively fully weight bearing in either a cast or removable boot. Following fracture union all patients had both anatomical alignment of the ankle mortise and good or excellent function. Radiographic results are shown in the table.

**Table.** Number (%) of patients with talar shift exceeding the given measurement, ie, false positives on GSRs

	4 mm	5 mm	6 mm
Absolute MCS only assessed	52 (78%)	24 (36%)	8 (12%)
MCS >1 mm more than SCS	32 (48%)	21 (31%)	7 (10%)
MCS >2 mm more than SCS	4 (6%)	4 (6%)	3 (4%)

**Conclusion:** The currently used criteria for measurements on stress radiographs result in high numbers of false-positive cases. This may lead to unnecessary surgery. Further investigation is required in order to identify other clinical or radiographic criteria that may be of use in the assessment of functional ankle stability after fracture.

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PAPER ABSTRACTS

**Early Routine Weight Bearing Is Safe in Patients With Ankle Fractures***Kate Ella Bugler; Timothy O. White, MD, FRCS;**Orthopaedic Trauma Unit, Royal Infirmary Edinburgh, Edinburgh, Scotland, United Kingdom*

**Background/Purpose:** Early weight bearing of patients with ankle fractures is associated with good outcomes. There are a number of potential advantages to early mobilization including reduced hospital stay, and earlier return to work and return to regular daily activities. However, many surgeons have not incorporated this into their routine ankle fracture protocol, particularly for patients managed operatively, potentially due to concerns regarding loss of reduction. We hypothesized that ankle fractures managed fully weight bearing would have good outcomes and a low rate of loss of reduction.

**Methods:** All ankle fractures presenting to our orthopaedic trauma department over a 15-month period were studied prospectively. Patients were instructed to mobilize fully weight bearing as able, either immediately postoperatively (for those fractures considered unstable that underwent operative intervention), or at the first fracture clinic review (if stable and managed conservatively). Only patients with syndesmotic injuries and those with neuropathy or psychiatric illness were excluded. The effectiveness of this management protocol was assessed by clinical and radiographic review following fracture union.

**Results:** 650 patients were included, with a mean age of 49 years, of whom 25% were over the age of 65 years. 35% of fractures were unstable and therefore managed operatively; 65% were stable and therefore managed in casts or with functional bracing. In every case, the radiographs showed maintenance of anatomic mortise and fracture reduction at the time of union.

**Conclusion:** Early weight bearing of patients with ankle fractures, whether managed conservatively or operatively, results in very low rates of loss of reduction and should be considered routine management for the majority of patients.



## Does the Fibula Need to Be Fixed in Complex Pilon Fractures?

*John C. Kurylo, MD; Neil Datta, Kendra N. Iskander, MD, MPH; Paul Tornetta, III, MD; Boston University Medical Center, Boston, Massachusetts, USA*

**Background/Purpose:** The classic teaching is that fixation of the fibula should be the first step in the surgical tactic for complex pilon fractures. However, with the advent of staged protocols including external fixators to maintain length and low-profile locked fixation it may not be necessary. The purpose of this study is to evaluate the effect of fibula fixation on alignment and complications in high-energy pilon fractures with tibial metaphyseal-seal dissociation.

**Methods:** From 364 patients with plafond fractures, 111 had high-energy injuries with metaphyseal dissociation and form the basis of the study. We identified three groups that had open reduction and internal fixation (ORIF) of the distal tibia: those with a fibula fracture that was fixed (26), those with a fibula fracture that was not fixed (37), and those without a fibula fracture (30). A fourth group of patients in whom the tibial metaphyseal reduction was supported definitively by external fixation (typically because the skin was not deemed amenable to surgical intervention) was reviewed to evaluate the effect of ORIF of the distal tibia in supporting the metaphysis. The radiographs and charts were reviewed for fracture characteristics; metaphyseal alignment at presentation, after fixation, and at union; surgical procedures; and complications. Complications included infection, fusion, hardware removal, compartment syndrome, and nonunion. A statistician performed comparisons among the groups. We compared complication rates and the alignment of patients with fibula fractures fixed to those who were not fixed and used patients without a fibula fracture as a control group to benchmark the results. The reason for fibula fixation, when chosen, was documented.

**Results:** Patients' average age was 42 years (range, 18-85) with 77 men and 34 women. There were no differences in patient demographics, fibula fracture pattern (oblique, transverse, or comminuted), or location (A, B, or C). There were 25 (23%) open fractures, all with a fibula fracture ( $P = 0.004$ ). Initial external fixation was used in 95 patients (85%). 60% of the plafond fixation was locked and no difference was found between the groups ( $P = 0.4$ ). Patients with initial valgus deformity were more likely to have their fibula fixed than those presenting in varus ( $P = 0.0015$ ). Of the 26 who had fibular fixation, 11 were staged at an average of 17 days after initial external fixation for inability to hold length or alignment in the frame. The other 15 were fixed at the time of the definitive plafond fixation to augment fixation (6), for soft-tissue prominence of the displaced fibula (3), or to aid in the reduction (6). We compared the overall alignment, maintenance of alignment, and complications among these groups (table). There was no difference in the ability to obtain a reduction or to maintain it to union when the fibula was or was not fixed ( $P = 0.5$ ). Neither group with fibula fractures had different alignment than the group without a fibula fracture ( $P = 0.92$ ). There was a higher overall complication rate if the fibula was fixed ( $P < .0001$ ). In the definitive external fixation group, 9 of 18 were open and 11 had fibular fixation to maintain length during their course. There were 15 complications in these 18 patients including 8 nonunions, 3 infections, 3 fusions, and 1 hardware removal. The average malalignment in this group at union or reintervention was  $7^\circ$  and different than those that had ORIF of

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the distal tibia ( $P < .001$ ). In contradistinction, union was achieved in all cases treated with ORIF of the tibia. The use of locking plates ( $P = 0.8$ ) did not affect the overall change in alignment during healing.

**Table.** Alignment as average absolute values, and complications in the groups that had tibial fixation

	<b>Fibula Fixed (26)</b>	<b>Not Fixed (37)</b>	<b>No Fibular Fracture (30)</b>	<b>P Value</b>
Postreduction alignment	1.6°	1.3°	1.5°	0.92
Alignment at union	2.1°	1.7°	1.9°	0.66
Change >5° after fixation	1 (3.8%)	0(0%)	2 (5.4%)	0.40
Total complications	11 (42%)	3 (8%)	4 (13%)	<0.0001
Infection	3 (11%)	3 (8%)	0 (0%)	0.08

**Conclusion:** Although it may be helpful in specific cases to augment initial external fixation or to aid in reduction, fibular fixation is not a necessary step in the reconstruction of pilon fractures. We found a higher rate of complications if the fibula was fixed ( $P < .0001$ ), without any benefit to reduction or maintenance of alignment. Finally, the use of external fixation as definitive support for the metaphyseal alignment resulted in a high percentage of nonunions (44%) and a more angular deformity than if plated.

## **Operative Treatment of Displaced Intra-Articular Calcaneal Fractures: Long-Term (10-20 Years) Results in 108 Fractures Using a Prognostic CT Classification**

*Roy Sanders, MD; Zachary Vaupel, MD;*

*Florida Orthopaedic Institute, Tampa, Florida, USA*

**Background/Purpose:** Although many short term studies using modern open reduction and internal fixation (ORIF) for displaced intra-articular calcaneal fractures (DIACFs) have shown an improvement in function, no study with long-term prospectively collected outcomes data exists. The purpose of this study was to evaluate the long-term (10-20 years) radiographic and functional outcome of patients after ORIF for DIACFs, and to determine whether the Sanders CT scan classification was still prognostic for outcome. The role of bone grafting and locked plating was also evaluated.

**Methods:** Isolated DIACFs managed with ORIF between January 1, 1990 and December 31, 2000 treated by a single surgeon were identified. All fractures were classified according to Essex-Lopresti, and Sanders et al. Surgery consisted of a lateral extensile approach, posterior facet (PF) reduction, lag screw fixation, and reduction of the anterior process / tuberosity with the application of a nonlocking lateral plate. No bone graft was used in any case. Articular (PF) reduction as measured by CT, Böhler angle, and Gissane angle was obtained postoperatively. At final follow-up (F/U) in 2011, all patients received plain radiographs, and a CT scan of the calcaneus. Functional assessment and outcome scores were obtained (Maryland, Short Form 36 [SF-36], and visual analog scale [VAS]), as well as all complications noted.

**Results:** 209 of 638 fractures met inclusion criteria: 108 fractures in 93 patients were available for F/U of a minimum 10 years (52%). Average F/U was 15.22 years (range, 10.5-21.2 years). 80 were joint depression (J) and 28 were tongue-type (T) fractures. There were 70 Sanders type II and 38 Sanders type III fractures. On immediate postoperative CT scan, PF reduction was anatomic in 103 fractures (95%), near anatomic in 3 fractures (1-3 mm), and approximate in 2 fractures (3-5 mm step). Long-term results indicated that only 2 fractures settled, at 4 and 7 years. No plates failed. There were no peroneal problems. Eight patients had sural neuritis. 12 fractures (11%) required local wound care for apical necrosis. One patient had a dehiscence resulting in osteomyelitis requiring a subtalar (ST) fusion. 31 fractures (29 patients) (29%) developed ST arthritis, requiring an arthrodesis (30 ST, 1 triple) for unrelenting pain (VAS, 8-10) during the F/U period. An ST fusion was performed in 47% of type III fractures (18 of 38) versus only 19% in type II (13 of 70) fractures ( $P = 0.002$ ). In fact, type III fractures were roughly four times more likely to need a fusion compared to type II (RR = 3.94; 95% confidence interval [CI], 1.64-9.48). The remaining 66 patients (77 fractures) were evaluated for long-term functional outcome. Only one patient used a cane, and only one (same patient) had a limp. 85% had returned to their previous lifestyle. 77% of patients (51 of 66) were within the US norm for the SF-36 physical component summary, with 46% (30 of 66) above the norm. Based on the Maryland Foot Score, 72% of patients had good to excellent results (27 excellent, 32 good, 13 fair, 4 failures). VAS scores of 0 to 2 (very little or no pain) were seen in 74% of the patients (49 of 66).

**Conclusion:** Based on the results of this long-term analysis, the Sanders classification remains useful. The need for subtalar arthrodesis after ORIF for DIACFs, despite equally accurate

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articular reductions, is such that at a minimum of 10 years, type III fractures were roughly four times more likely to need a fusion compared to type II fractures. It appears that neither a locked plate nor bone graft are required to maintain a reduction over time, as virtually no loss of reduction was seen in this series. If posttraumatic subtalar arthritis does not occur, good long-term (10-20 years) functional results with little pain, a normal gait, and a return to previous lifestyle can be expected from a properly performed ORIF.

## **A New Look at the Hawkins Classification for Talar Neck Fractures: Which Features of Injury and Treatment Are Predictive of Osteonecrosis?**

*Stephen G. Reichard, MD; Heather A. Vallier, MD; Alyse J. Boyd, MA;*

*Timothy A. Moore, MD;*

*MetroHealth Medical Center, Cleveland, Ohio, USA*

**Background/Purpose:** Despite improvements in surgical techniques, including usage of dual anteromedial and anterolateral exposures and versatile implants, talar neck fractures remain challenging injuries to manage. Osteonecrosis (ON) and posttraumatic arthrosis (PTA) are reported commonly. Initial fracture displacement and length of time dislocated versus the time until definitive fixation have been considered potential risk factors for ON. The purpose of this study was to review a large series of talus fractures, reduced expeditiously, but definitively managed with delay whenever possible to allow for improvement in soft-tissue swelling. We hypothesized that delay of fixation would not increase the risk of ON, but that initial fracture displacement, including subtalar and/or tibiotalar dislocations would be predictive. We propose dividing the Hawkins II classification into subluxed subtalar joint (IIA) and dislocated subtalar joint (IIB).

**Methods:** Records of 80 patients with 81 talar neck and or body fractures treated with open reduction and internal fixation (ORIF) at a Level I trauma center over 10 years were reviewed. 40 women and 40 men with mean age of 36.7 years (range, 17-72) had 78 talar neck fractures: 2 Hawkins I, 40 Hawkins II (17 IIA and 23 IIB), 32 Hawkins III, 1 Hawkins IV, 2 Hawkins IIB with an associated talonavicular dislocation, and 4 patients had displaced talar body fractures. Open fractures occurred in 24 patients (29.6%). A two-incision approach was used in 92%, and 95% of patients were stabilized with mini- and/or small-fragment implants. Comorbidities, fracture characteristics, and timing of reductions, provisional and definitive, were recorded. Complications including wound healing problems, infections, nonunions, malunions, ON, and PTA were noted.

**Results:** Patients were assessed after a mean 21.2 months' follow-up. One patient (1.2%) developed deep infection, and two patients each had nonunion (2.4%) and malunion (2.4%). 15 of 81 fractures (18.5%) developed ON, but 60% of these revascularized without collapse. ON did not occur in any patients without subtalar dislocation (Hawkins I and IIA), but 24% of those with Hawkins IIB patterns developed ON ( $P = 0.03$ ), and 29% of Hawkins III fractures developed ON. ON occurred after 29% of open fractures versus 14% of closed fractures ( $P = 0.12$ ). 46 fractures (57%) were treated with urgent ORIF at a mean of 10.1 hours after injury (range, 5-24 hours), most because of open fractures and/or irreducible dislocations. Timing of reduction within 6, 8, 12, or 18 hours after injury was not related to risk of ON. 35 patients were treated with delayed ORIF at a mean of 10.6 days, including 9 Hawkins IIB and 9 Hawkins III fractures initially reduced with closed  $\pm$  percutaneous methods at a mean of 9.5 hours after injury. Only 1 of these 18 patients developed ON (5.6%). 31 patients (38%) had some radiographic evidence of PTA, including 45% of those with associated talar body fracture, and 59% of Hawkins III injuries.

**Conclusions:** Treatment for fractures of the talus has evolved over recent years. Open fractures and dislocations irreducible through closed methods should be treated urgently.

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However, we recommend careful attention to fracture alignment through open reduction, performed on a delayed basis when initial soft-tissue swelling is severe, as long as dislocations have been reduced. Delaying fixation in such cases does not increase the risk of ON. ON was associated with initial fracture displacement, and separating Hawkins II fractures into those with (IIA) and without (IIB) subtalar dislocation was predictive of ON. ON never occurred when the subtalar joint was not dislocated. The majority of ON cases revascularized without talar dome collapse.

## **A Prospective, Randomized Controlled Trial of the Acumed Fibular Nail Versus Standard Open Reduction and Internal Fixation for Fixation of Ankle Fractures**

*Timothy O. White, MD, FRCS; Kate E. Bugler; Paul T. Appleton, MD; Margaret M. McQueen, MD; Charles M. Court-Brown, MD; Edinburgh, Scotland, United Kingdom*

**Purpose:** The technique of open reduction and internal fixation (ORIF) of ankle fractures with plates and screws has not changed substantially since the 1960s. Three principal complications are associated with this type of surgery. Firstly, wound dehiscence and infection, with published rates of up to 30%, and higher rates in patients with diabetes and neuropathy. Secondly, there is a risk of construct failure, particularly in osteoporotic bone. Thirdly, the scar or prominent hardware may cause later irritation and require further surgery. We have developed a technique of intramedullary fibular nailing that is biomechanically stronger than ORIF, requires only minimal incisions, and has low-profile hardware. We hypothesized that fibular nailing would result in a rate of reduction and union comparable to fixation, with a reduced rate of wound and hardware problems.

**Methods:** 100 patients over the age of 65 years with unstable ankle fractures requiring fixation were recruited and randomized to undergo fibular nailing or standard stabilization using AO techniques. Immediate weight bearing in cast was permitted. Outcome measures assessed over the 12 postoperative months were: the accuracy of reduction, development of wound complications or radiographic arthritis, range of movement, Olerud and Molander score (OMS), and the total cost of treatment. The mean age was 74 years (range, 65-93) and 75 patients were women. Twelve patients were smokers, two were diabetic, and all had some form of comorbidity, most commonly hypertension or ischaemic heart disease. Three injuries occurred during sport and one after a fall from a height; the remainder occurred after a simple fall from a standing height. 72 patients underwent additional medial fixation.

**Results:** Significantly fewer wound infections occurred in the fibular nail group ( $P = 0.002$ ). Eight patients (16%) in the ORIF group developed lateral-sided wound infections and required antibiotics. Two of these developed a wound dehiscence and required readmission for surgical débridement and removal of metalwork. In addition, six further patients complained of discomfort related to their wounds or hardware. One patient suffered surgical division of the superficial peroneal nerve and one patient went on to a malunion. No infections or wound problems occurred in the fibular nail group. One patient underwent reoperation during the index admission for loss of reduction, one patient complained of a prominent locking screw, and one patient developed a malunion. The overall cost of treatment in the fibular nail group was less despite the higher initial cost of the implant. At 1 year, fibular nail patients were significantly more happy with the condition of their scar ( $P = 0.02$ ), and had slightly better OMS scores (63 vs 61, not significant [ $P = 0.61$ ]).

**Conclusion:** The fibular nail allows accurate reduction and secure fixation of ankle fractures with a significantly reduced rate of soft-tissue complications when compared with standard ORIF.

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### Δ Can We Tell If the Syndesmosis is Reduced Using Fluoroscopy?

Paul Tornetta III, MD; Scott Koenig, MD; Gabriel Merlin; Yelena Bogdan, MD;  
Boston University Medical Center, Boston, Massachusetts, USA

**Background/Purpose:** Reduction of the ankle mortise correlates with outcomes for unstable ankle fractures. Increased emphasis has been placed on the reduction of the syndesmosis as well as not missing subtle syndesmotic injury. Several authors have highlighted the use of lateral views to aid in determining if the fibula is in its proper position with respect to the tibia. The purpose of this study was to evaluate the ability of surgeons to determine if the fibula is reduced, anteriorly displaced, or posteriorly displaced based on fluoroscopic images by comparison with the known normal for both the ipsilateral and contralateral ankles.

**Methods:** Perfect lateral radiographs of both ankles were obtained in 7 cadaveric specimens (14 ankles). These were confirmed by two evaluators independently rotating an image intensifier until the plafond had only one clear surface. In all cases, the angulation was  $<2^\circ$  different, confirming the ability to predictably obtain a "perfect lateral." After saving these images, a Kirschner wire (K-wire) was placed in both the distal tibia and the distal fibula to be used later to measure fibular translation. The deltoid and syndesmotic ligaments were then sectioned and the fibula was translated 2.5 mm and 5 mm in the anterior and posterior directions by changing the distance between the K-wires with calipers for a precise displacement. A perfect lateral radiograph was taken at each displacement and saved (5 images / side). Each ankle was used as a case consisting of a "normal" image, followed by 10 randomly selected images (random number generator). These images could be taken from the ipsilateral or contralateral ankle for that specimen and could be any of the 10 images. Images could also be repeated (random generator). Within each set of 10 images, the initial "normal" image and the contralateral ankle "normal" image were always included to test for ability to determine the reduced position. Four orthopaedic trauma fellowship-trained surgeons from different Level I centers reviewed each case. They were asked to compare the 10 images to the normal image and determine if the fibula was "reduced," "displaced anteriorly," or "displaced posteriorly." The ability of the surgeons to identify displacement and interobserver reliability were assessed for the 560 test images.

**Results:** See table below for summary. The surgeons were better able to identify malreduction than reduction, with negative predictive values (correctly identifying malreduction) of 95% for ipsilateral ankle images and 85% for contralateral images. The overall sensitivity for reduction was 94% for the ipsilateral ankle but only 68% for the contralateral ankle, although the range was great among reviewers (32%-100%). Anterior displacement was easier to see than posterior displacement (positive predictive value [PPV] = 90% vs 77% for ipsilateral and 90% and 71% for contralateral). Greater displacements were easier to see with PPV for 2.5 mm and 5.0 mm being 76% and 93% for ipsilateral and 71% and 91% for contralateral ankles. All reviewers had the most difficulty with 2.5 mm of posterior displacement, correctly identifying posterior malreduction in 27% to 64%. The overall agreement between reviewers (using Kappa values) was excellent for anterior displacement (0.71) and for displacements of 5 mm in either direction (0.75), and only moderate for the other displacements and for



the reduced position (0.51-0.6). The overall PPV and negative predictive value (NPV) for various displacements is shown in the table.

	Reduced	Anterior	Posterior	2.5-mm Displaced	5.0-mm Displaced
PPV	70%	90%	75%	74%	92%
NPV	90%	83%	77%	78%	83%

**Conclusion:** Four experienced trauma surgeons evaluated known translational displacements of the fibula against the normal ankle radiographs using a verified perfect lateral view. Their ability to determine malreduction was 90%, but their ability to confirm reduction was only 70%. Minor posterior displacement was the most difficult to identify. While it is unknown how much translational displacement of the syndesmosis is acceptable, it seems that experienced surgeons will most often be able to reduce the joint within 2.5 mm and that fluoroscopic comparisons to the normal ankle are helpful in determining malreduction.

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**Anatomic Reduction of the Syndesmosis: What Values to Trust?**

*Jonah Hebert-Davies, MD<sup>1,2</sup>; Marie-Lyne Nault, MD<sup>1,2</sup>; George Yves Laflamme, MD<sup>1</sup>; Stephane Leduc, MD<sup>1</sup>;*

<sup>1</sup>*Hopital du Sacre-Coeur, Montreal, Quebec, Canada*

<sup>2</sup>*University of Montreal, Montreal Quebec, Canada*

**Background/Purpose:** Anatomic reduction of the fibula with regard to the tibia has become the goal of treating syndesmotic injuries. Several studies have recently questioned our capacity to do so, implying that malreduction is much more common than originally thought. These studies focus on postoperative CT scans to show wide-ranging variation. Our hypothesis is that there exists a wide range of anatomic variation in the syndesmosis and this might lead to overly critical opinion of postreduction CT scans. The purpose of this study is to first describe and validate radiologic measurements to evaluate the syndesmosis reduction and establish normal values.

**Methods:** Ankle CT scans of 100 normal ankles were evaluated. The scans were originally done to evaluate patients with foot trauma but without documented ankle trauma. A series of eight measurements was devised based on previously published studies or described by our group. These criteria measure both anterior and lateral position of the fibula and rotation with regard to the tibia. Two independent reviewers evaluated all scans and all measurements were recorded initially. A third evaluator reviewed 30 scans to validate interobserver reliability and measurements were repeated at 6 weeks for intraobserver reliability.

**Results:** We found that the most reproducible measurement was the ratio of anterior to posterior gaps between tibia and fibula with a mean value of 0.603 and an intraclass correlation coefficient (ICC) of 0.879. This is the normal value and could eventually change with malreduction in rotation or specific anterior (AITFL) or posterior inferior tibiofibular ligament (PITFL) rupture. A mean central lateral distance of 2.8 mm was found and the ICC for that measure was also excellent (ICC = 0.75). A mean rotation index (defined as the angle between both malleoli at ankle level) was of 7.5° with ICC of 0.662. All other results were reproducible with good intra- and interobserver reliability with interclass correlations between 0.61 and 0.746.

**Conclusion:** Several studies have shown that reduction of the syndesmosis is essential to restore normal ankle mechanics and prevent secondary degenerative changes. Our results show that a significant amount of variability exists in the anatomical position of the syndesmosis. The evaluation criteria developed in the study can give the surgeon a guideline for evaluating postoperative reductions.

## **The Effect of Syndesmosis Screw Removal on the Reduction of the Distal Tibiofibular Joint**

*CPT Daniel J. Song, MD; CPT Joseph T. Lanzi, MD; MAJ Adam T. Groth, MD; MAJ Matthew Drake, MD; LTC Joseph R. Orchowski, MD; COL Kenneth K. Lindell, MD; Tripler Army Medical Center, Honolulu, Hawaii, USA*

**Background/Purpose:** Injury to the tibiofibular syndesmosis is frequent with rotational ankle injuries. Although there is controversy regarding the treatment of these injuries (size of screws, number of cortices, composition of screws, postoperative weight bearing, need and timing for screw removal), many studies show statistically significant improvements in subjective and objective outcomes with anatomic reduction of the syndesmosis. In a retrospective radiographic study in 2006, Gardner et al reported a 52% syndesmotic malreduction rate in their 25-patient cohort. The purpose of this study is to prospectively evaluate syndesmotic reduction with CT, and determine the effect of screw removal on both the anatomically reduced and malreduced syndesmosis.

**Methods:** This is an IRB-approved prospective radiographic study. Patients over 18 years of age treated at one institution between August 2008 and December 2011 with intraoperative evidence of syndesmosis disruption were enrolled. Postoperative CT scans were obtained within 2 weeks of operative fixation of the injured and uninjured ankle. A second CT scan was then obtained 30 days after syndesmosis screw removal. All CT scans were evaluated by a single musculoskeletal radiologist to evaluate the reduction of the syndesmosis. Using axial CT images, differences of more than 2 mm between the anterior and posterior fibula-incisura distances were considered malreduced in accordance with the standard established by Gardner et al.

**Results:** 25 patients were enrolled in this prospective study. The average age was 25.7 (range, 19-35), with 3 females and 22 males. Eight patients (32%) had evidence of tibiofibular syndesmosis malreduction on their initial postoperative axial CT scans. In the postsyndesmosis screw removal CT scan, seven of eight (87.5%) of malreductions showed adequate reduction of the tibiofibular syndesmosis.

**Discussion/Conclusions:** Tibiofibular syndesmosis injuries are common with ankle fractures and require surgical fixation. In 2006, Gardner et al showed an alarming 52% tibiofibular syndesmosis malreduction rate on immediate postoperative CT scans. In 2004, Weening and Bhandari reported a much lower 16% malreduction rate using plain radiographs, and also showed that adequate reduction of the syndesmosis was the only statistically significantly predictor of functional outcome. To our knowledge, this study is the only prospective study to report the effect of syndesmosis screw removal on tibiofibular syndesmosis reduction. Similar to Gardner et al, we also found a high rate of tibiofibular syndesmosis malreduction of 32%. Despite this high rate of initial malreduction, 87.5% of the malreduced syndesmoses spontaneously reduced after screw removal. Further correlation with functional outcomes is necessary. Syndesmotic screw removal may be advantageous to achieve final anatomic reduction of the distal tibiofibular joint and continues to be recommended.

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**A Comparison of Weight-Bearing Protocols and Outcomes for Syndesmotic Ankle Fixation: 6 Weeks Versus 12 Weeks**

*Jeffrey E. McAlister, DPM; Jeff E. Schulman, MD; Noah Oliver, DPM; A. Stephen Malekzadeh, MD; Cary A. Schwartzbach, MD; Matthew S. Levine, MD; Daniel Dziadosz, MD; Robert Hymes, MD; Orthopedic Trauma Program, INOVA Fairfax Hospital, Falls Church, Virginia, USA*

**Purpose:** This retrospective analysis was designed to evaluate two weight-bearing protocols, 6 weeks versus 12 weeks of non-weight bearing (NWB), following syndesmotic fixation at a Level I trauma center. The primary outcome measure was failure of syndesmotic reduction. Our hypothesis was that there would be no significant difference between the two postoperative protocols.

**Methods:** All patients with syndesmotic injuries (with and without associated ankle fracture) who underwent operative fixation at a Level I trauma center between February 2007 and September 2010 were reviewed. Data, including age, mechanism of injury, and other demographics, were extracted from the medical record. Radiographs were evaluated preoperatively, immediately postoperatively, and at 2, 6, 12, and 18 weeks postoperatively for tibiofibular clear space (TFCS) and medial clear space (MCS). Key study measurements were defined as those measured from immediate postoperative radiographs and those taken 6 weeks after the initiation of weight bearing (12 weeks vs 18 weeks postoperatively for the 6- and 12-week cohorts, respectively). Clinical failure was defined as complete loss of reduction requiring revision surgery. Data were statistically compared using a two-tailed paired *t* test and Fisher exact test with significance set to *P* <0.05.

PAPER ABSTRACTS

Cohort	#	Age, y	Open Fractures	Tobacco Use	OTA Classification		Clinical Failures	MOR for MCS, mm	MOR for TFCS, mm
					A	B			
6-week	39	46.3 (15-77)	5	8	A	1	3/39 (7.6%)	-0.16 (12-wk radiograph)	-0.09 (12-wk radiograph)
					B	19			
					C	19			
12-week	27	39.1 (17-76)	7	7	A	0	1/27 (3.7%)	-0.25 (18-wk radiograph)	0.17 (18-wk radiograph)
					B	10			
					C	17			
<i>P</i> value							0.64	0.83	0.003

MOR = maintenance of reduction = difference between postop radiograph and 6 weeks after initiation of weight bearing (negative numbers → loss of reduction, positive numbers → tightening on radiograph).

**Results:** 146 syndesmoses were repaired during the data collection period. 100 had complete clinical follow-up and of these, 66 had complete data for radiographic evaluation. Three patients from the 6-week cohort and one from the 12-week cohort failed clinically and went on to early surgical revision. Radiographic comparison revealed no statistical

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difference between the maintenance of reduction (MOR) for the MCS ( $-0.16$  mm vs  $-0.25$  mm,  $P = 0.83$ ) whereas there was statistical significance for the MOR of the TFCS ( $-0.09$  mm vs  $0.17$  mm,  $P = 0.003$ ).

**Conclusion:** This retrospective review is the first of its kind to compare two postoperative weight-bearing protocols after syndesmotic fixation. We demonstrated statistical significance for maintenance of TFCS with a longer postoperative non-weight-bearing period, but no significance for MCS. Some literature suggests that MCS may be more clinically relevant. Despite this, we question whether there is true clinical significance in either of these cohorts given the magnitude of difference being measured on radiographs ( $<0.5$  mm). Ultimately, the number of true clinical failures was low in both cohorts with no statistical significance ( $7.6\%$  vs  $3.7\%$ ,  $P = 0.64$ ). We feel that weight bearing at 6 weeks after surgical repair of a syndesmosis is a viable option, particularly in certain patient populations that may benefit most from an earlier return to activity.

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**SATELLITE VIDEO CONFERENCE and AWARD PRESENTATION  
WITH ITALIAN SOCIETY OF ORTHOPAEDICS  
AND TRAUMATOLOGY HOSPITALS (OTODI)**

*Robert A. Probe, MD  
OTA President*

*Francesco Biggi, MD  
OTODI Past President*



**Periprosthetic Fracture Treatment: An Update (When and How to Fix  
the Fracture vs Implant Revision) on Hip and Knee**

*George J. Haidukewych, MD*

NOTES

**JOHN BORDER MEMORIAL LECTURE**

**Orthopaedic Trauma – My Perspective”**

***James F. Kellam, MD, FRCS(C), FACS***

*Vice Chairman, Department of Orthopaedic Surgery,*

*Director of the Orthopaedic Trauma Program,*

*Carolinas Medical Center, Charlotte, North Carolina, USA*

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**SKILLS LABS**

**ORIF Distal Radius Fractures (#F3)**

Moderator: *Erik N. Kubiak, MD*

Faculty: *Greg Altman, MD; Eric W. Fulkerson, MD; Michael D. McKee, MD; Amer J. Mirza, MD and Milak K. Sen, MD*

**ORIF Distal Tibia and Fibula Fractures (#F4)**

Moderator: *J. Tracy Watson, MD*

Faculty: *Mark J. Anders, MD; David E. Karges, DO; Frank A. Liporace, MD; Steven J. Morgan, MD and Anthony S. Rhorer, MD*

**SIGN – Surgical Implant Generation Network (#F5)**

Moderator: *Lewis G. Zirkle, MD*

Faculty: *Duong Bunn, MD; Luigi A. Sabal, MD; Robert S. Schultz, MD; Faseeh Shahab, MD; Prof Shahab-uddin, MD; Carla S. Smith, MD and Frederic B. Wilson, Jr, MD*

NOTES



**MINI SYMPOSIA**

**US Policy and Healthcare Reform: An Update**

Moderator: *Manish K. Sethi, MD*

Faculty: *A. Alex Jahangir, MD; Hassan R. Mir, MD and Steven A. Olson, MD*

**Periprosthetic Fractures**

Moderator: *Michael D. McKee, MD*

Faculty: *George J. Haidukewych, MD*

*Hans J. Kreder, MD; William M. Ricci, MD and Emil H. Schemitsch, MD*

**Infections with Resistant Bacteria – Are They Winning the Battle?**

Moderator: *Stephen L. Kates, MD*

Faculty: *Volker Alt, MD; Edward Schwarz, PhD and Michael Suk, MD, JD, MPH*

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### **Intra-Articular Inhibition of Interleukin-1 Prevents Posttraumatic Arthritis Following Articular Fracture in the Mouse Knee**

*Daniel S. Mangiapani, MD; Evan M. Zeitler, BA; Bridgett D. Furman, BS; Janet L. Huebner, MS; Virginia B. Kraus, MD, PhD; Farshid Guilak, PhD; Steven A. Olson, MD;*

*Duke University Medical Center, Durham, North Carolina, USA*

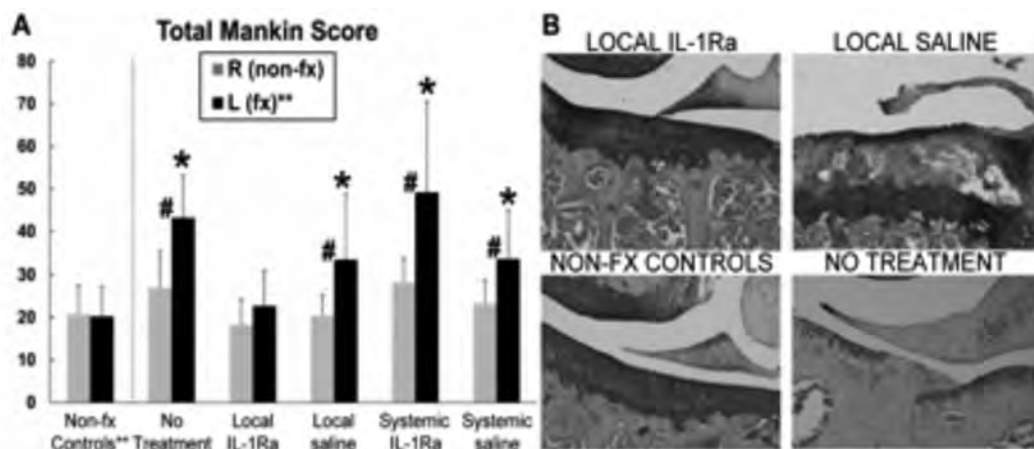
**Purpose:** Posttraumatic arthritis (PTA) is an accelerated form of osteoarthritis that commonly follows joint trauma, such as articular fracture. While the mechanisms underlying joint degeneration are not fully understood, we have developed a mouse model that predictably induces PTA and suggests that proinflammatory cytokines such as interleukin-1 (IL-1) play a role in its pathogenesis. We hypothesized that exogenous inhibition of systemic or local IL-1 acutely following articular fracture will reduce arthritic changes in the joint.

**Methods:** Male C57BL/6 mice (n = 48) were subjected to a closed intra-articular fracture (fx) of the tibial plateau using an established protocol. Immediately following fracture, IL-1 receptor antagonist (IL-1Ra) was administered using a continuous systemic infusion of either IL-1Ra (n = 12) or saline (n = 11) for 4 weeks. A second group received a single intra-articular injection of either IL-1Ra (n = 9) or saline (n = 8) immediately following fracture. A group with fracture only and no treatment was also included (n = 8), as well as nonfracture controls (n = 3).

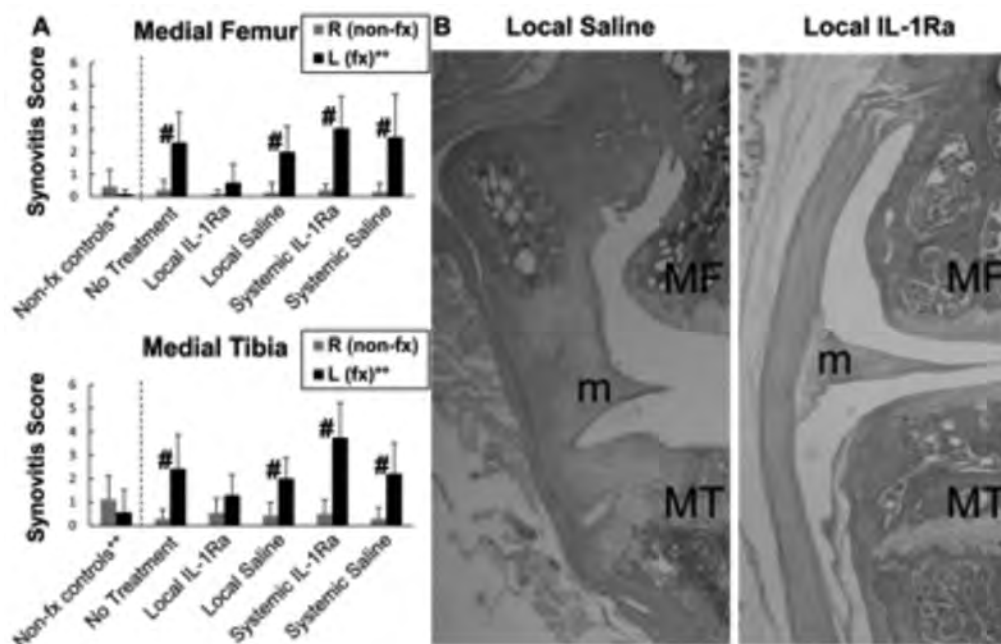
**Results:** Mice who received a single intra-articular injection of IL-1Ra demonstrated significantly reduced cartilage degeneration in the fractured knee compared to all other treatment groups except nonfracture controls (Figure 1, A). Furthermore, the local IL-1Ra group qualitatively displayed preserved articular cartilage compared to the other treatment groups (Figure 1, B). Mice receiving local IL-1Ra demonstrated reduced synovial inflammation in the medial femur and medial tibia with no statistical difference from the contralateral nonfractured knee (Figure 2, A). Furthermore, the local IL-1Ra group qualitatively displayed reduced inflammatory changes in the synovium compared with other treatment groups receiving fractures (Figure 2, B).

**Conclusion:** The observation that local administration of IL-1Ra immediately following fracture prevented arthritic changes suggests a critical role of intra-articular and synovial inflammation in the development of PTA. Furthermore, our results are consistent with observations of the MRL/MpJ strain that is protected from PTA. This study may provide evidence for conducting larger clinical trials of anticytokine therapy for acute joint trauma.

**Acknowledgements:** Arthritis Foundation; NIH AR50245, AG15768, AR48852, AR48182.



**Figure 1 A**  
Total Mankin score, all treatment groups. \* $P < 0.05$  compared to local IL-1Ra. # $P < 0.05$  compared to right (non-fx) limb. \*\*Left limb not fractured in non-fx controls. B, Safranin O/fast green staining of left (fx) limb.



**Figure 2 A**  
Synovitis score; # $P < 0.05$  compared to right limb; \*\*left limb not fractured in non-fx con-

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### **Δ The Severity of Microvascular Dysfunction Due to Compartment Syndrome Is Diminished by the Systemic Application of CO-Releasing Molecules (CORM-3)**

*Abdel-Rahman Lawandy, MD; Relka Bihari, MSc; David W. Sanders, MD, PhD; Gediminas Cepinskas, PhD; London Health Sciences Centre, London, Ontario, Canada*

**Background/Purpose:** Compartment syndrome (CS) is a limb-threatening complication of musculoskeletal trauma, resulting in myonecrosis and cell death. Both ischemic and inflammatory pathways have been implicated in the microvascular dysfunction and parenchymal injury seen in CS. Urgent fasciotomy remains the only treatment for CS. Recently, carbon monoxide (CO) has been shown to protect microvascular perfusion and reduce inflammation in ischemic states in animal models. Unfortunately, exogenous administration of CO via inhalation results in increased carboxyhemoglobin levels (COHb), reducing the clinical applicability. Transitional metal carbonyls, or CO-releasing molecules (CORM), deliver CO in a controlled manner without altering COHb, and can be administered using various routes (intravenous, intraperitoneal [IP], subcutaneous, or tissue superfusion) to target specific tissues. The purpose of this study was to examine the protective effects of CO, liberated from a novel CORM-3 on the function of CS-challenged muscle in a rodent model. The ultimate goal is the development of a pharmacologic adjunctive treatment for CS, which would reduce the morbidity and disability in patients.

**Methods:** 20 male adult Wistar rats were randomized into 3 groups: sham (no CS, n = 4), CS (with inactive CORM-3, n = 8), and CS + CORM-3 (10 mg/kg IP, n = 8). CS was induced by elevation of intracompartmental pressure (ICP) to 30 mm Hg through an infusion of isotonic saline into the anterior compartment of the hind limb for 2 hours. Both CORM-3 and inactive CORM-3 were injected immediately following fasciotomy. Microvascular perfusion (% continuously perfused, intermittently perfused, and nonperfused capillaries), cellular injury (ethidium bromide:bisbenzimidazole staining, EB/BB), and inflammatory response (adherent and rolling leukocytes in venules) within the extensor digitorum longus muscle (EDL) were assessed using intravital video microscopy (IVVM) 45 minutes after fasciotomy (5 fields of view in each animal). Data were analyzed using one-way analysis of variance.

**Results:** Elevation of ICP resulted in significant microvascular perfusion deficits ( $23 \pm 2\%$  continuously perfused capillaries in CS vs  $76 \pm 4\%$  in sham,  $P \leq 0.0001$ ;  $55 \pm 2\%$  nonperfused capillaries in CS versus  $13 \pm 2\%$  in sham,  $P \leq 0.0001$ ), increased tissue injury (EB/BB of  $0.31 \pm 0.05$  in CS vs  $0.05 \pm 0.03$  in sham,  $P \leq 0.0001$ ), and adherent leukocytes ( $13.7 \pm 0.9$  in CS vs  $1.8 \pm 0.5$  in sham,  $P \leq 0.0001$ ). CORM-3 treatment was able to restore the number of continuously perfused capillaries ( $57 \pm 5\%$ ,  $P \leq 0.001$ ), diminish tissue injury (EB/BB of  $0.07 \pm 0.01$ ,  $P \leq 0.001$ ), and decrease leukocyte adherence ( $0.6 \pm 0.3$ ,  $P \leq 0.001$ ).

**Conclusion:** Application of CORM-3 to CS-challenged muscle resulted in restoration of microvascular perfusion, 8-fold decrease in leukocyte activation, and 4-fold decrease in tissue injury. The data suggest that there may be a potential therapeutic application of CORM-3 to patients at risk of developing CS.

Δ OTA Grant

See pages 97 - 144 for financial disclosure information.

### Can Glucose Levels Diagnose Compartment Syndrome?

**Christopher J. Doro, MD<sup>1</sup>**; **Thomas J. Sitzman, MD<sup>2</sup>**; **Robert V. O'Toole, MD<sup>3</sup>**;

<sup>1</sup>Department of Orthopaedics, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin, USA;

<sup>2</sup>Division of Plastic Surgery, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin, USA;

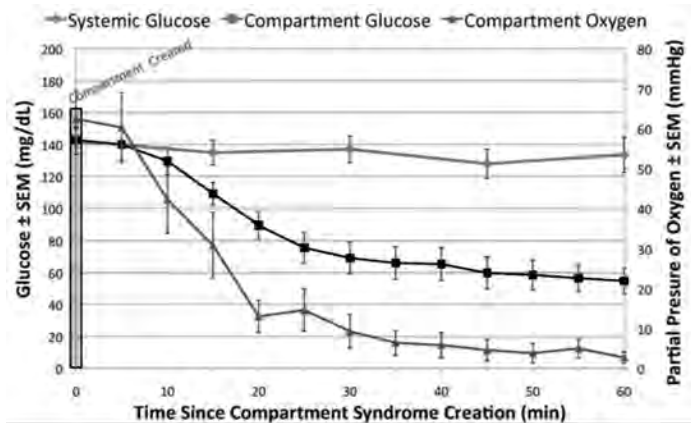
<sup>3</sup>R Adams Cowley Shock Trauma Center, Department of Orthopaedics, University of Maryland School of Medicine, Baltimore, Maryland, USA

**Purpose:** Compartment syndrome is a difficult condition to diagnose, particularly in patients without a reliable clinical examination. Current objective methods rely on intracompartmental pressure measurements. We hypothesize that intracompartmental glucose levels can be used to diagnose compartment syndrome.

**Methods:** A compartment syndrome was created in 12 adult mixed-gender beagles using a previously described and validated model. Compartment syndrome was created in the anterior compartment of a lower leg in anesthetized dogs by infusion of lactated Ringer's solution with normal serum concentration of glucose until intracompartment pressure exceeded 20 mm Hg above diastolic blood pressure. The contralateral leg was used as a control. Intracompartmental pressure, oxygen tension, and glucose concentration were recorded within each compartment using commercially available probes (Medtronic Diabetes; Oxford Optronix). Compartment syndrome was confirmed in all cases by histologic analysis at 2 weeks after the infusion.

**Results:** Within 15 minutes of creating the compartment syndrome, glucose concentration in the experimental limb measured significantly lower than the control limb (glucose P = 0.02; 2-tailed t test). Intramuscular glucose concentration less than 97 mg/dL was 100% (95% confidence interval [CI]: 73%-100%) sensitive and 75% (95% CI: 40%-94%) specific for the presence of compartment syndrome.

**Conclusions:** Our results show that the intracompartmental glucose concentration appears to rapidly identify muscle ischemia after an experimentally created compartment syndrome. Real-time glucose sensors could provide a significant advancement to the diagnosis of compartment syndrome by providing objective data that accurately and quickly indicate the presence of muscle ischemia, as opposed to relying on pressure measurements that are a much less direct indicator of ischemia.



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PAPER ABSTRACTS

•Local Bismuth Thiols Potentiate Antibiotics and Reduce Infection in a Contaminated Open Fracture Model

Jowan Penn-Barwell, MRCS<sup>1</sup>; Brett Baker, MSc, DC<sup>2</sup>; Joseph C. Wenke, PhD<sup>3</sup>;

<sup>1</sup>Royal Centre for Defence Medicine, Birmingham, United Kingdom;

<sup>2</sup>Microbion Corporation, Bozeman, Montana, USA;

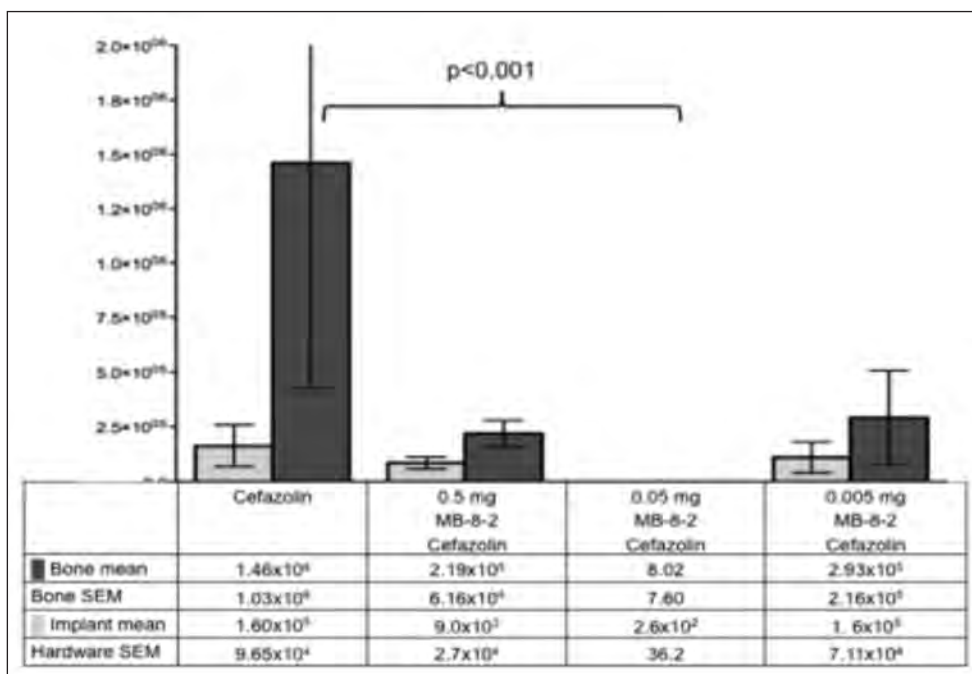
<sup>3</sup>U.S. Army Institute of Surgical Research, Fort Sam Houston, Texas, USA

**Purpose:** This study screened different types and concentrations of Bismuth Thiols (BTs) for ability to potentiate systemic antibiotics in reducing infection in open fractures. We hypothesized that BTs would potentiate systemic antibiotics because BTs are known to reduce biofilms, one of the major barriers for antimicrobial success.

**Methods:** A segmental defect rat femur model contaminated with Staphylococcus aureus and treated with surgical débridement 6 hours after injury and 3 days of systemic cefazolin was used. BTs suspended in a hydrogel were added to the wound immediately after débridement. After 14 days, the bone and implant were harvested for microbiologic analysis. The principal outcome was the quantity of bacteria on the implant or bone.

**Results:** Of the 3 formulations of BTs screened, the formulation with the best profile of low toxicity and high antimicrobial effect was retested at a range of doses. A dose of 0.05 mg when combined with systemic cefazolin resulted in 0.02% of the bacterial quantity of the cefazolin only group (P <0.001), with the rate of detectable bacteria in wounds dropping from 60% to 10% (P = 0.0022), and no observable local and systemic toxic effects.

PAPER ABSTRACTS



See pages 97 - 144 for financial disclosure information.

**Conclusion:** BTs at an appropriate dose can potentiate the effect of antibiotics at reducing infection rate and bacteria quantity.

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### Eradication of Wound Contamination Is Improved by Synergistic Effects of Local and Systemic Antibiotic Delivery.

Ben C.C. Rand, MRCS<sup>1,2</sup>; Jowan G. Penn-Barwell, MRCS<sup>1,2</sup>; Joseph C. Wenke, PhD<sup>1</sup>;

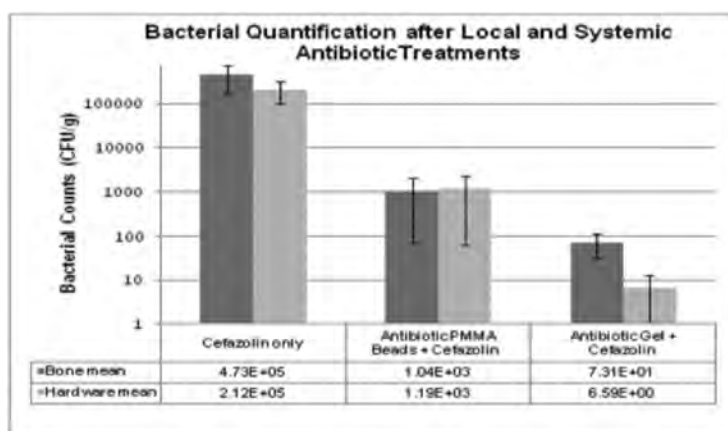
<sup>1</sup>U.S. Army Institute of Surgical Research, Fort Sam Houston, Texas, USA;

<sup>2</sup>Academic Department of Military Surgery and Trauma, Royal Centre for Defense Medicine, Birmingham, United Kingdom

**Background/Purpose:** Eradication of contaminating bacteria to a level manageable to the host immune system is vital in preventing chronic infection and its complications. Appropriate use of systemic antibiotics reduces infection rates in open fractures but local delivery can deliver higher doses to the wound without toxic systemic effects and may further reduce infection. We wished to quantify the effect in combination to confirm the synergy presumed by clinicians. Although the gold standard for local antibiotic delivery is with impregnated polymethylmethacrylate (PMMA) beads, a biodegradable vehicle would be better, negating the need for additional surgery required with beads. Our hypothesis was that an investigational biodegradable antibiotic gel would have a superior synergistic effect to antibiotic PMMA beads, when used in conjunction with systemic antibiotics.

**Methods:** An established rat open fracture model with a *Staphylococcus aureus*-contaminated critical-sized femoral defect was used. The wounds were débrided and irrigated 6 hours after contamination and the animals were assigned to one of three groups, all of which received systemic antibiotics: antibiotic gel, antibiotic PMMA beads, and the no local delivery control group. DFA-02 is an investigational phospholipid vehicle containing 1.7% vancomycin and 1.9% gentamicin by weight that has been shown to be more effective than beads used as a sole therapy. PMMA beads contained vancomycin and tobramycin (the aminoglycoside used in PMMA beads in the U.S.). Systemic antibiotics (cefazolin 2 mg/kg twice daily) were commenced at the time of débridement surgery and were continued for 3 days postoperatively. At 2 weeks from initial surgery, the animals were euthanized, the femur and hardware were stripped of soft tissue, and bacterial levels were quantified using standard microbiologic analysis.

**Results:** Local antibiotics used in combination with systemic were superior ( $P < 0.05$ ) to systemic antibiotics alone. Between antibiotic gel and PMMA bead groups there was no statistically significant difference when used with systemic antibiotics; however, there was two orders of magnitude fewer bacteria in the hardware group.



See pages 97 - 144 for financial disclosure information.



**Conclusions:** These results suggest that local antibiotics can add value to systemic antibiotic use. Previous work demonstrated that the antibiotic gel was much more effective than antibiotic beads in this preclinical model without use of systemic antibiotics; it appears that systemic antibiotic administration slightly blunts the differences between beads and gel. While the difference between PMMA bead and gel treatment groups is not significant in this model with systemic antibiotics, gel offers handling advantages due to its ready to use formulation and biodegradable nature.

**Animal Statement:** This study has been conducted in compliance with the Animal Welfare act, the implementing Animal Welfare Regulations, and the principles of the Guide for the Care and Use of Laboratory Animals.

**Disclaimer:** The opinions and assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or Department of Defense. Dr. Reddy's Laboratories Ltd. kindly donated the experimental material for use in this study.

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**Chitosan: An Effective NPWT-Compatible Local Antibiotic Delivery Device***Ben C.C. Rand, MRCS<sup>1,2</sup>; Scott P. Noel, PhD<sup>3</sup>; Joseph C. Wenke, PhD<sup>1</sup>;*<sup>1</sup>*U.S. Army Institute of Surgical Research, Fort Sam Houston, Texas, USA*<sup>1,2</sup>*Academic Department of Military Surgery and Trauma, Royal Centre for Defense Medicine, Birmingham, United Kingdom;*<sup>3</sup>*Bionova Medical, Memphis, Tennessee, USA*

**Purpose:** Antibiotic-loaded polymethylmethacrylate (PMMA) beads are not an ideal antibiotic vehicle, and negative pressure wound therapy (NPWT) has been shown to reduce their effectiveness. It appears that negative pressure removes the eluted antibiotic from the wound before it can diffuse throughout the wound. We hypothesized that antibiotic-impregnated chitosan sponges would effectively reduce bacteria when used with NPWT due to its increased contact with the wound surface.

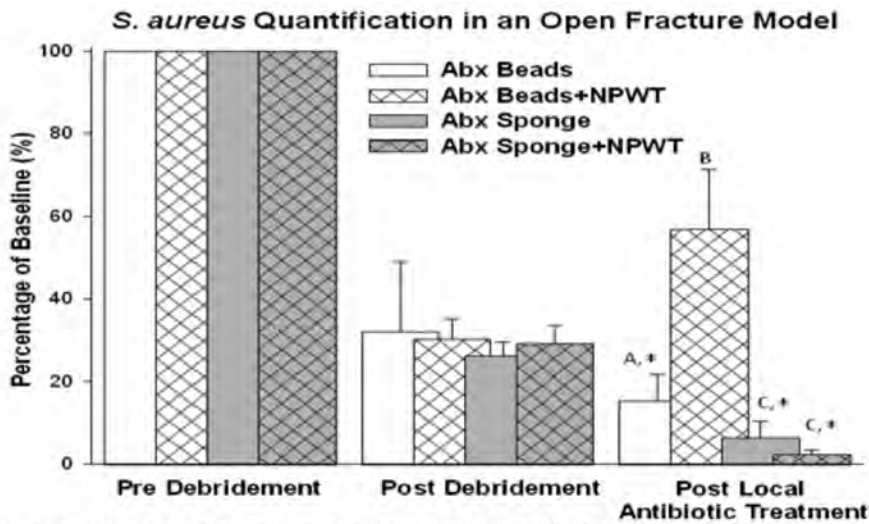
**Methods:** The effectiveness of PMMA antibiotic beads was compared to antibiotic loaded chitosan sponge, used in both wound pouch and NPWT modalities. A complex tibial open fracture wound was created in goats and inoculated with *Staphylococcus aureus*. The wounds were débrided at 6 hours, and the bacteria was quantified both pre- and postdébridement. The animals were assigned to a group, and the bacteria within the wound were requantified after 2 days. The four groups were: antibiotic bead pouch, antibiotic beads with NPWT, chitosan sponge pouch, and chitosan sponge with NPWT. Both the beads and sponges contained vancomycin.

**Results:** There were significantly fewer bacteria within the wounds treated with chitosan sponge compared with antibiotic beads irrespective of use in a pouch or with NPWT. Unlike beads, the effectiveness of chitosan sponges was not reduced by NPWT.

**Conclusion:** This study demonstrates that a biodegradable chitosan sponge loaded with vancomycin is superior to antibiotic-impregnated beads at eradicating *S. aureus* in a complex large animal wound model, whether used in conjunction with NPWT or in a wound pouch. It also offers advantages in handling, antibiotic choice, device removal, and its effect is not reduced when used with NPWT. We believe that the sponge is more effective because more surface area is in contact with the wound surface where the antimicrobial agents can act. PMMA beads act as a depot, eluting antibiotic that must diffuse throughout the wound. When used with NPWT, the antibiotic is removed before it can reach the bacteria not in contact with the beads. The increased contact with the wound surface of the chitosan sponge allows improved antimicrobial action both with and without NPWT, and the difference in effectiveness is more pronounced with NPWT.

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Percentage of Baseline photon counts representing quantification of bacterial presence in the complex musculoskeletal goat tibial wound. Each letter (i.e. "A") signifies that groups result is significantly different to all groups labelled with an alternate letter (B, C). The presence of a \* symbol signifies that within that group, the treatment effect itself was statistically significant.

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## Comparison of Standard Iliosacral Screw Fixation to Transsacral Locked Screw Fixation in a Type C Zone II Pelvic Fracture Model With Residual Fracture Site Separation

*Sean A. Tabaie, MD; Gary Bledsoe, PhD; Berton R. Moed, MD;  
Saint Louis University School of Medicine, Saint Louis, Missouri, USA*

**Purpose:** Iliosacral screw fixation into the first sacral body is a preferred method for pelvic ring fixation. However, this construct has been shown to be clinically unreliable for the percutaneous fixation of unstable Type C zone II vertically oriented sacral fractures with residual fracture site separation. The purpose of this study was to biomechanically compare a locked transsacral construct versus the standard iliosacral construct in a Type C zone II sacral fracture model.

**Methods:** A Type C pelvic ring injury was created in 10 cadaver pelvises by performing vertical osteotomies through zone II of the sacrum and the ipsilateral pubic rami. The sacrum was then reduced maintaining a 2-mm fracture gap. Five specimens were fixed using two 7.0-mm iliosacral screws into the S1 body; the other five were fixed using one 7.0-mm iliosacral screw and one 7.0-mm transsacral screw exiting the contralateral ilium with a nut placed on its end, creating a locked construct. Each pelvis underwent 100,000 cycles at 250 N and was then loaded to failure using a unilateral stance testing model. Vertical displacements at 25,000, 50,000, 75,000, and 100,000 cycles and failure force were recorded for each pelvis. The differences between the two groups were compared using the Mann-Whitney *U* test.

**Results:** The mean displacements at 25,000, 50,000, 75,000, and 100,000 cycles and force to failure for the iliosacral group were 5.1 mm, 9.6 mm, 15.5 mm, 19.7 mm and 825 N respectively. Comparatively, the values for the transsacral group were 3.6 mm, 5.5 mm, 10.2 mm, 15.5 mm and 1056 N. The locked transsacral construct performed significantly better than the iliosacral construct at all four measurement points ( $P = 0.009$ ) and in force to failure ( $P = 0.02$ ).

**Conclusion:** Fixation of unstable Type C zone II sacral fractures using the combination of an iliosacral screw and a locked transsacral screw resists deformation and withstands a greater force to failure as compared to fixation with two standard iliosacral screws. This locked transsacral construct may prove advantageous, especially when a percutaneous technique is used for a Type C zone II vertically oriented sacral fracture injury pattern, which can result in residual fracture site separation.

**Short Segment Fixation of an L1 Compression Fracture: Four Versus Six Screws**

*Seth K. Williams, MD<sup>1</sup>; Robert P. Norton, MD<sup>1</sup>; Edward L. Milne, BSc<sup>2</sup>;  
David N. Kainrajh, MS<sup>2</sup>; Frank Eismont, MD<sup>1</sup>; Loren L. Latta, MD, PhD<sup>1,2</sup>;  
<sup>1</sup>Department of Orthopaedics, University of Miami, Miami, Florida, USA;  
<sup>2</sup>Max Biedermann Institute for Biomechanics, Miami Beach, Florida, USA*

**Purpose:** The standard configuration for posterior short segment fixation involves pedicle screws placed above and below the fracture. However, loss of correction and hardware failure have been reported. In a series of 19 patients treated with short segment fixation, bending of the screws occurred in 6 patients, progressive kyphosis in 3 patients, and screw breakage in 1 patient. We hypothesize that placing pedicle screws at the level of the fracture posteriorly can improve the rigidity of the fixation.

**Methods:** 13 fresh-frozen human cadaveric spines (donor ages 20 to 60 years at time of death) were thawed and manually stripped of the paraspinal muscles, leaving the facet joints, capsules, and interspinous ligaments intact. The spines were separated at the T11-12 and L2-3 discs, leaving an intact segment from T12 through L2. Multiple holes were drilled in the L1 vertebral body in order to compromise its integrity and allow for the production of an isolated compression fracture. The vertebral column segment was then placed between metal plates and an incremental axial displacement was applied via an MTS Mini-Bionix II Model 858 servohydraulic testing machine until a compression fracture at L1 with a residual vertebral height loss of at least 50% was produced. Fluoroscopy was used to confirm a persistent height loss of at least 50% after the load was removed. The posterior elements were intact to visual inspection. The specimens were instrumented with 6-mm pedicle screws connected to 5.5-mm titanium rods. Selspot LED emitters were fixed to T12 and L2 to measure their motion in 6 degrees of freedom, from which the relative movements between T12 and L2 could be calculated. Uniaxial strain gauges were bonded to the rods to monitor longitudinal strain in the segment of rod between the T12 and L1 screws, and between the L1 and L2 screws. A 400-N follower preload was employed to simulate the stabilizing forces produced by paraspinal musculature. Specimens were cyclically loaded from 5 N·m extension to 5 N·m flexion, well within their elastic range. Two conditions were tested: (1) 4-screw construct: no screws at the L1 fractured body (4S); (2) 6-screw construct: screws at all levels (6S). The two groups were compared statistically by paired t test.

**Results:** The mean stiffness in flexion and extension was 13.42 N/mm with the 4-screw construct and 17.37 N/mm with the 6-screw construct ( $P < 0.03$ ). This represented a 31% increase in construct rigidity with the addition of the 2 screws in L1. Relative movement of T12 compared to L2 was evaluated in terms of vertical translation and sagittal rotation between both groups and no significant difference was found between the 4S and 6S constructs. With screws at L1, rod strain was significantly increased between L1-L2 ( $P < 0.001$ ), but not between T12-L1.

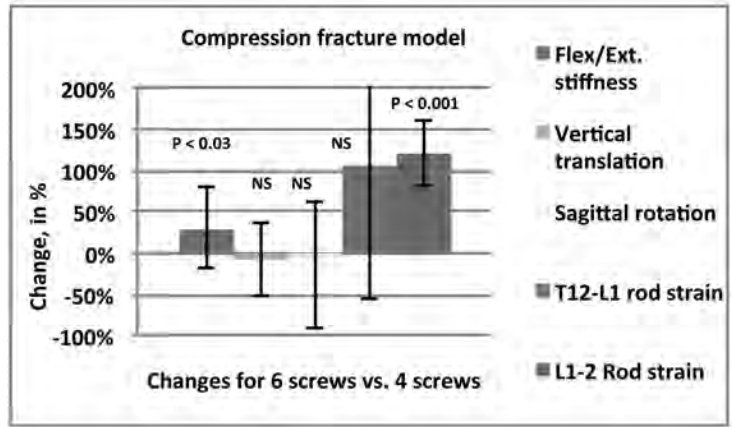
**Discussion/Conclusion:** The goal of placing additional screws in a fractured vertebral segment is to decrease the chance of mechanical failure with short segment constructs. The addition of screws at a fractured L1 segment increases the rigidity of fixation and places

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more of the load on the rods, but distributes the load over 50% more screws, which may decrease the potential for loosening of the screws. In a cadaveric L1 compression fracture model, a 6-screw construct with 2 screws in the injured vertebral body is biomechanically superior to a 4-screw construct that skips the injured body.

**Figure**

The percent change from 4 screws to 6 screws for each parameter showed significant increases in structural stiffness and rod strains between L1 and T12.



**MINI SYMPOSIA**

**Plateaus and Pylons: The Posterior Perspective**

Moderator: *Stephen A. Kottmeier, MD*

Faculty: *Clifford B. Jones, MD; Paul Tornetta, III, MD and J. Tracy Watson, MD*

**Tools and Tips for Maximizing Physician Assistant Utilization**

*Tricia Marriott, PA-C, MPAS, DFAAPA,*

*Interim Vice President of Constituent Organization Development;*

*Director Reimbursement Advocacy; American Academy of Physician Assistants*

Faculty: *Dennis Gregory, PA; Debra Sietsema, PhD, RN and Keith Zurmehly, PA*

**Compensation Formulas: What Works and What Doesn't**

Moderator: *William R. Creevy, MD*

Faculty: *Timothy J. Bray, MD; M. Bradford Henley, MD and Roy Sanders, MD*

NOTES

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## Functional Outcomes After Nonoperative Treatment of Lateral Compression Type 1 (LC-1) Pelvic Ring Injuries With Complete Sacral Fractures

Greg Gaski, MD; Robert V. O'Toole, MD; Renan Castillo, MS; Gerard P. Slobogean, MD; Theodore T. Manson, MD;  
R Adams Cowley Shock Trauma Center, Baltimore, Maryland, USA

**Purpose:** There is controversy regarding the optimum management of LC-1 fractures (OTA 61-B2), particularly for those with complete sacral fractures. Our hypothesis was that nonoperative treatment of these injuries would result in acceptable functional outcomes.

**Methods:** We conducted a review of a prospectively maintained database at a Level I trauma center over 3 years (2008-2011) to identify all LC-1 fractures (n = 315). We identified a subset of "more severe" LC-1 injuries characterized by complete fracture through Denis zones 2 or 3 of the sacrum (n = 76). Of these, 12 patients were managed operatively at the discretion of the treating surgeon due to fracture displacement greater than 1 cm or severe comminution, and are not included in this analysis. The 64 remaining patients with complete sacral fracture and displacement less than 1 cm were treated nonsurgically and form the population of interest. Two patients were excluded due to spinal cord injury and 6 patients were deceased, leaving 56 potential patients. 30 patients were successfully contacted for functional outcome assessment at an average follow-up of 24.4 months (range, 15-37). The mean age at time of injury was 38.8 years (range, 17-80). Primary outcome measures were the Majeed Pelvic Score and the Physical and Mental Component Summary scores (PCS and MCS) of the Short Form-12 v.2. Bivariate analyses were performed with respect to age, ISS, anterior pelvic ring injury (none/unilateral rami fractures vs bilateral), associated lower extremity (LE) injuries, and initial weight-bearing status (non vs weight bearing as tolerated).

**Results:** The average Majeed Pelvic Score was 81.7 (95% confidence interval [CI]: 75.1 to 88.4) yielding 19 excellent, 4 good, 3 fair, and 4 poor graded outcomes. Mean PCS and MCS scores were 46.9 (95% CI: 42.4, 51.3) and 48.2 (95% CI: 44.5, 51.8), respectively. Both intervals included 50, the mean score for a healthy, normative population. Patients with LE injuries had lower PCS scores than patients without LE injuries (38.1 vs 50.0,  $P = 0.04$ ), and were less likely to have an "excellent" Majeed score (2 of 8 vs 17 of 22 in the non-LE injury group,  $P = 0.009$ ). Additionally, all Majeed "poor" outcomes were in the subgroup of patients with concomitant LE injuries. There were no statistically significant differences in regard to weight-bearing status, anterior ring injury, or ISS.

**Conclusion:** Recent studies have shown that "more severe" LC-1 fractures are susceptible to future displacement, but the clinical consequence of nonoperative treatment is unknown. This study suggests that good outcomes can be expected with nonsurgical management of "more severe" LC-1 fractures with less than 1 cm of initial displacement. Improvement in long-term functional outcome does not seem to be a valid rationale to treat these injuries operatively.



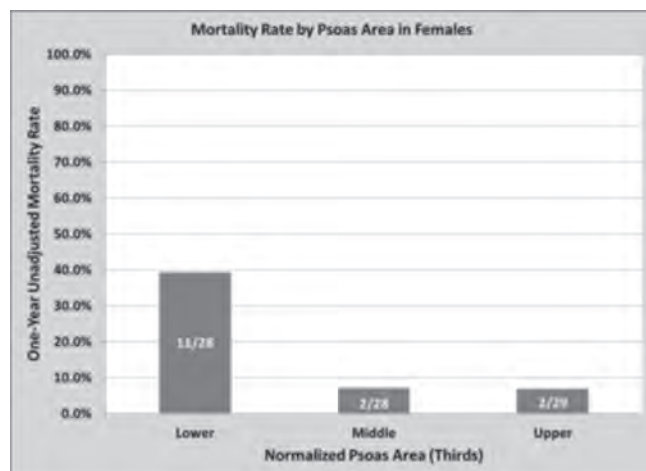
## Core Muscle Size and Mortality Following Nonoperative Management of Pelvic Fractures

William D. Scheidler, BS; Shaun P. Patel, BS; Sven A. Holcombe, BS;  
Stewart C. Wang, MD, PhD; James A. Goulet, MD;  
University of Michigan, Ann Arbor, Michigan, USA

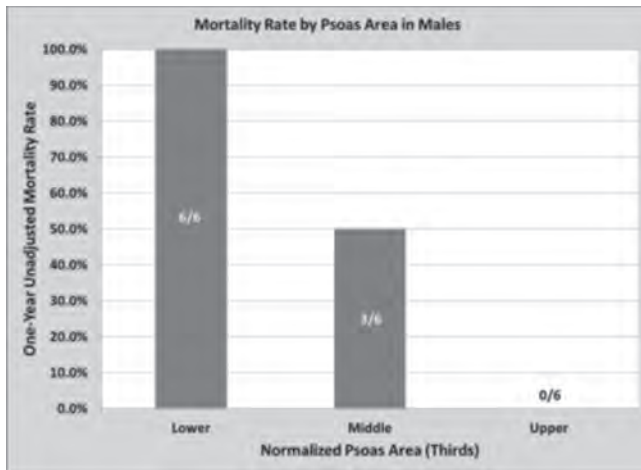
**Background/Purpose:** The incidence of pelvic fractures in the United States is estimated to be 37 cases per 100,000 person-years. In the geriatric population, 94% of pelvic fractures are low-impact, osteoporotic fractures. One out of every five geriatric patients dies within 1 year of their pelvic fracture. While fracture risk can be estimated through bone densitometry, there are limited data predicting postfracture survival. Core muscle size, a proxy measure of patient frailty, may serve as one such variable to help risk-stratify patients. Specifically, we hypothesized that decreased core muscle size would lead to increased mortality.

**Methods:** We identified 405 patients undergoing nonoperative management of a pelvic fracture at the University of Michigan Health System between February 2004 and January 2011 who had a CT scan of their abdomen/pelvis within 90 days of their diagnosis. To select for low-impact injuries in an osteoporotic population, we included only females over age 50 and men over age 65 with an ISS <18. Our primary independent variable was core muscle size, defined as the total cross-sectional area of the psoas muscles at the level of the fourth lumbar vertebra (L4), normalized to height to account for body type variance. Our dependent variable of interest was 1-year mortality following the fracture. Bivariate analyses were subsequently performed.

**Results:** 103 patients met our selection criteria (85 females, 18 males). 24 patients (15 female, 9 male) died within 1 year of their diagnosis (23.3% overall, 17.6% female, 50% male). When stratifying females into thirds by normalized psoas area, the patients in the lower third had a significantly higher 1-year mortality rate compared to patients in the upper third (39.3% vs 6.9%,  $P = 0.0001$ ). When similarly stratifying males, the patients in the lower third also had a significantly higher 1-year mortality rate compared to patients in the upper third (100.0% vs 0.0%,  $P = 0.002$ ).



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**Conclusions:** In nonoperatively managed pelvic fractures, our data indicate that decreased core muscle size leads to significantly increased mortality rates. Such objective measures of patient frailty may potentially inform clinical decision-making and improve orthopaedic patient risk stratification.

**• Transiliac-Transsacral Screw Fixation in C-Type Pelvic Ring Injuries Reduces Postoperative Failure**

**Gregory Y. Blaisdell, MD<sup>1</sup>**; James C. Krieg, MD<sup>2</sup>; Milton L. Chip Routt Jr, MD<sup>2</sup>;

<sup>1</sup>University of Washington Department of Orthopaedics and Sports Medicine, Seattle, Washington, USA;

<sup>2</sup>Harborview Medical Center, Seattle, Washington, USA

**Purpose:** Vertically unstable pelvic ring injuries (OTA 61-C) have been challenging to treat with standard iliosacral screw technique over time. These injuries are at risk for early postoperative displacement despite adequate reduction and fixation. Up until late 2005, cannulated screws of sufficient length to traverse the entire length of the posterior pelvic ring using S1 or S2 pathways were not available. Transiliac-transsacral screw use has been increasingly utilized with the goal of more durable fixation. We hypothesized that transiliac-transsacral screw fixation of OTA 61-C injuries would reduce the short-term complications compared with the use of iliosacral screws alone.

**Methods:** We studied two groups of 61-C injuries retrospectively. The iliosacral-only group (IS) included obviously vertically displaced pelvic ring injuries from January 1 to December 31, 2005. This time period was the last consecutive year in which transiliac-transsacral screws had not come into use. The transiliac-transsacral group (TI-TS) included vertically displaced pelvic ring injuries treated between October 1, 2009 and September 31, 2010 with at least one transiliac-transsacral screw. Careful scrutiny of injury films to avoid inclusion of lateral compression injuries produced 19 patients for the 2005 group and 15 patients for the 2010 group. All U-, Y-, and H-type sacral fractures were excluded. Failure in fixation was determined to be a combined displacement of 1 cm on the inlet and outlet films at final follow-up compared to immediate postoperative films.

**Results:** The IS group consisted of 19 patients with 23 C-type hemipelvis injuries, 11 of which were complete sacral fractures, 4 were sacroiliac dislocations, and 8 were sacroiliac fracture-dislocations. The TI-TS group consisted of 15 patients with 22 C-type hemipelvises, of which 6 were complete sacral fractures, 8 sacroiliac fracture-dislocations, and 8 sacroiliac dislocations. Posterior fixation in the IS group consisted of 41 screws all in the upper sacral segment. The TI-TS group consisted of 40 screws, 27 TI-TS screws (14 in S1 osseous pathway, 13 in S2 pathway) and 13 iliosacral screws all in the upper sacral segment. There were no cases of screw intrusion into the S1 or S2 foramina or alar cortical breach in either group. Failures of fixation occurred in 53% of the IS patients (10 of 19 patients, average 20-mm displacement) and 20% of TI-TS patients (3 of 15 patients, average 14-mm displacement). There was one nonunion in the IS group that required bone grafting and repeat fixation. There was one infected fibrous union in the TI-TS group that was stable on radiographs and asymptomatic upon hardware removal. In the IS group, two bent and one broken iliosacral screws were noted at final follow-up, and one bent screw was noted in the TI-TS group. There were nine loose washers in each group at final follow-up, but only one screw that had measurably backed out (TI-TS patient). This screw was removed as an outpatient procedure.

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**Conclusions:** OTA 61-C type pelvic ring injuries are challenging to treat, and are associated with a high rate of postoperative displacement. Compared with iliosacral screws, transiliac-transsacral screw fixation decreases the number of fixation failures, without changing the safety profile of the fixation type. Assuming adequate reduction to allow safe placement, this fixation type should be strongly considered for vertically unstable injuries.

**Transiliac-Transsacral Screw Safe Zone Diameter in 1091 Sacrum***John J. Lee, MD; Alex Martusiewicz, MD; James A. Goulet, MD;**University of Michigan, Department of Orthopedic Surgery, Ann Arbor, Michigan, USA*

**Background/Purpose:** Iliosacral screw fixation from an iliac cortex to the sacral body for posterior pelvic disruptions may not provide adequate stabilization in certain injury patterns and in the osteoporotic. Longer transiliac-transsacral screws spanning across the sacrum and bilateral iliac cortices may provide increased stability and can be placed percutaneously with a low complication rate. Placement of these screws, however, is technically challenging due to the small window, or safe zone, which these screws must traverse to avoid devastating neurovascular injury. Pelvic dysmorphism and other anatomic variations may preclude the safe placement of these screws. We present the results of a novel method for measuring the safe zone for transiliac-transsacral screw placement in the upper and second sacral segments.

**Methods:** 1091 adult ( $\geq 18$  years old) pelvis CT scans obtained from our trauma registry were morphometrically analyzed automatically with MATLAB software. Each pelvis was oriented in the anatomic position, bisected, and the left and right sides were analyzed separately, assuming the sacrum to be perfectly symmetric. If a unilateral sacral fracture was present, the uninjured side was used for analysis. Patients with bilateral sacral fractures were excluded. A maximum diameter intraosseous cylinder that traversed the sacrum perpendicular to the sagittal plane was calculated for the upper and second sacral segments. Pelvises were grouped into a normal or a lumbarized group depending on the absence or presence of a lumbarized S1. Safe zone diameters for normal and lumbarized were compared. A safe zone diameter of 10 mm was used as the critical threshold for safe placement of a large cannulated screw (6.5 mm to 8.0 mm).

**Results:** Data are presented as mean ( $\pm$ standard deviation). Of 1091 patients, 672 (62%) were male and 419 (38%) female. Mean age was 36 ( $\pm 16$ ) years. 64 (5.9%) were identified as lumbarized. Safe zone diameters in normal was 14.0 ( $\pm 3.9$ ) mm in S1 and 10.7 ( $\pm 3.7$ ) mm in S2 and in the lumbarized, 17.2 ( $\pm 3.7$ ) mm in S1 and 9.7 ( $\pm 2.5$ ) mm in S2 ( $P < 0.0001$  for S1 between groups). Of normal pelvises, 17% were below the critical safe threshold in S1 and 38% in S2, whereas in the lumbarized pelvises 3% were below in S1 and 51% in S2. Of the normal pelvises that cannot take an S1 screw, 34% can safely take an S2 screw. 6% of normal pelvises can safely take two large cannulated screws in the upper sacral segment while 18% could do so in the lumbarized group. Second sacral segments in either group cannot accept two large screws.

**Conclusion:** 83% of normal pelvises and 97% of lumbarized S1 pelvises can accept a large cannulated transiliac-transsacral screw safely in S1 while 62% of normal and 49% of lumbarized pelvises can accept a large cannulated screw safely in S2. This method is superior to prior methods in that the pelvis is analyzed three-dimensionally with an intraosseous cylinder.

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### Is Closed Reduction and Percutaneous Fixation of Type 3 Posterior Ring Injuries as Accurate as Open Reduction and Internal Fixation?

Adam Lindsay, MD<sup>1</sup>; Paul Tornetta, III, MD<sup>1</sup>; Amna Diwan, MD<sup>2</sup>; David C. Templeman, MD<sup>2</sup>;

<sup>1</sup>Boston University Medical Center, Boston, Massachusetts, USA;

<sup>2</sup>Hennepin County Medical Center, Minneapolis, Minnesota, USA

**Background/Purpose:** Type 3 posterior ring injuries are complete injuries and typically treated with reduction and internal fixation. While open treatment through a posterior approach allows for direct fracture reduction and is the gold standard, many surgeons are employing more percutaneous approaches. We compared closed reduction and percutaneous fixation (CRPP) versus open reduction and internal fixation (ORIF) of type 3 posterior ring injuries with the hypothesis that CRPP would be equivalent to ORIF in quality of reduction.

**Methods:** We reviewed 113 consecutive cases of unilateral unstable posterior ring injuries treated by two physicians in two different centers with iliosacral (IS) screws. Only true type 3 injuries were included. One surgeon routinely performed ORIF (n = 60); and the other, CRPP (n = 53). These two groups were compared. For all cases, demographic information, time to surgery, type of injury, and type of fixation was documented. Displacements were measured on the initial presentation and postoperative AP, inlet, and outlet views. These included the differences in the affected side from the normal side for: iliac wing height (AP, outlet), sacral height (AP), posterior superior iliac spine (PSIS) displacement (inlet), ischial height (AP, outlet), ring width (AP, inlet), and sacral width (inlet). These were compared with two-tailed *t* test assuming 0.05 for significance. *CRPP Technique:* A special traction setup was used that has not been previously described. The patient is positioned supine with a bump under the affected thorax and all the way to the edge of the table to allow easy placement of IS screws. The normal side foot is placed in a boot and the heel elevated to keep the knee in extension and locked there. Skeletal traction with ~20° to 30° of flexion is used on the affected side. A specially adapted hip positioning pad is locked to the table and abuts the affected thorax to prevent lateral displacement of the thorax when traction is applied. Under fluoroscopy, the posterior reduction can be titrated using traction as the unaffected leg acts as a post and the thorax pad prevents angulation of the body as the traction is applied to the affected side. Once the reduction is obtained, IS screws are placed. *ORIF Technique:* The patient is positioned prone on pads to allow free manipulation of the pelvis. A gluteus maximus-sparing approach was used in all cases. Clamps are used to directly reduce the posterior ring, augmented by fluoroscopy, and IS screws are placed.

**Results:** There were 53 patients treated with CRPP and 60 with ORIF during the study period. The ages (average, 36.9 years; range, 13-71), gender (62 female, 51 male), and ISS scores (average, 22.4; range, 4-59) did not differ between the groups. Initial displacements were also not different for the two groups (see table). The time to surgery was 4 days (range, 0-16) for the CRPP group and 5 (range, 0-36) for the ORIF group. Overall reduction quality was slightly better for the CRPP method for most parameters tested.

	Preoperative			Postoperative		
	ORIF	CRPP	<i>P</i> Value	ORIF	CRPP	<i>P</i> Value
	Iliac Wing Height (AP)					
Avg ± SD, mm	9.0 ± 8.9	8.2 ± 5.8	0.57	6.3 ± 5.0	1.9 ± 1.2	<0.001
	Iliac Wing Height (Outlet)					
Avg ± SD, mm	9.1 ± 8.2	10.6 ± 6.6	0.27	4.1 ± 5.5	2.6 ± 1.6	0.03
	PSIS Displacement (Inlet)					
Avg ± SD, mm	7.4 ± 7.0	8.9 ± 6.6	0.23	3.9 ± 4.3	2.4 ± 1.5	0.02
	Ischial Height (Outlet)					
Avg ± SD, mm	9.0 ± 5.4	9.2 ± 5.3	0.89	4.1 ± 5.5	2.8 ± 1.8	0.10
	Ring Width (Inlet)					
Avg ± SD, mm	8.1 ± 5.7	6.9 ± 6.4	0.27	6.0 ± 4.4	4.1 ± 3.6	0.01

SD, standard deviation.

**Conclusions:** We compared the radiographs of two senior surgeons' series of type 3 posterior pelvic injuries. One treated patients with standard ORIF and the other with CRPP. We found no differences in the initial displacements or demographics. The final reduction was statistically better with CRPP for most parameters; however, these differences likely have no clinical significance as the largest average difference was <5 mm. We conclude that CRPP done as described is as effective as the gold standard of prone ORIF in obtaining an accurate reduction of type 3 posterior pelvic ring injuries.

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## Displaced Sacral Fractures: Do Long-Term Radiologic Findings Correlate to Neurologic Deficits and Pain?

Aron Adalved, MD<sup>1,5</sup>; Anna Tötterman, MD, PhD<sup>2</sup>; Thomas Glott, MD<sup>3</sup>;

Johan C. Hellund, MD, PhD<sup>4</sup>; Jan Erik Madsen, MD, PhD<sup>5</sup>; Olav Røise, MD, PhD<sup>5</sup>;

<sup>1</sup>Orthopaedic Department, Akershus University Hospital, Akershus, Norway;

<sup>2</sup>Orthopaedic Department, Karolinska University Hospital, Stockholm, Sweden;

<sup>3</sup>Department for Spinal Cord Injuries, Sunnaas Hospital, Nesodden, Norway;

<sup>4</sup>Radiologic Department, Oslo University Hospital, Oslo, Norway;

<sup>5</sup>Orthopaedic Department, Oslo University Hospital, Oslo, Norway

**Background/Purpose:** Long-term neurologic deficits and pain are common after high-energy sacral fractures. However, little is known about the correlation between these long-term clinical outcomes and radiologic findings. The aim of the present study was to assess whether long-term radiologic findings after surgically treated displaced sacral fractures correlated with pelvic-related pain or neurologic dysfunctions in the lower extremities and the perineum.

**Methods:** 28 consecutive patients with displaced (>1 cm) sacral fractures were followed for mean 10.7 years (range, 8.1-13.4) postinjury. Two had H-type sacral fractures, while 26 had AO/OTA type-C pelvic ring disruptions involving the sacrum. In 27 of 28, the sacral fractures were transforaminal. All fractures were treated with reduction and internal fixation. Sensorimotor impairments in the lower extremities were classified according to the American Spinal Injury Association (ASIA) and pain was assessed using a visual analog scale (VAS) ranging from 0 to 10. CT and plain radiograph images were scrutinized for nonunion, cranial and posterior residual displacement, and ankylosis/osteoarthritis (OA) in the L5-S1 facet joints and the sacroiliac joints. Changes of sacral configuration, including narrowing of the L5 and sacral neural foramina, as well as postforaminal encroachment of L5 and S1 nerves were recorded. The statistical analyses were calculated using Spearman correlation coefficients.

**Results:** No sacral nonunions were encountered. Residual cranial displacement >10 mm was present in 13 patients (46%) averaging 15.4 mm (range, 10-28). Posterior displacement averaging 18.9 mm (range, 11-35) was observed in 10 (36%). In the L5-S1 facet joints, OA was present in 18 (64%), and ankylosis in 9 (32%). 26 (93%) had narrowing of one or more neural root foramina L5-S4. According to the VAS, 8 patients (29%) reported no pain. Of the remaining 20, 11 had only pain in the lumbosacral (LS) area and 9 had a combination of LS and radiating pain in the L5-S2 dermatomes. A statistically significant correlation was found between the narrowing of the sacral neural foramina and neurologic deficits in corresponding dermatomes (S1:  $P = 0.03$ , S2:  $P < 0.001$ , S3:  $P = 0.001$ ). In L5 dermatomes, a significant correlation was found between postforaminal affection of L5 nerves for both sensory ( $P = 0.025$ ) and motor ( $P = 0.01$ ) deficits correspondingly. No statistically significant correlations were found between pain and any of the pathologic radiologic findings.

**Conclusions:** In patients with surgically treated sacral fractures, persistent lumbosacral pain is common, but does not correlate to radiologic sequelae after fracture healing or residual displacement in the posterior pelvic ring. However, pathologic radiologic findings



involving the neuroforamina correlate significantly to neurologic deficits. This suggests that reconstruction of the sacral neural foramina at the time of surgery may play a greater role in the long-term outcome compared to overall pelvic alignment. Further studies are needed to assess the natural history of these secondary changes involving the sacral neural foramina.

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## Appropriateness of Angiography and Embolization in the Management of High-Energy Pelvic Ring Injuries

*Sean M. Griffin, MD; Kenneth J. Nelson, MD; Bryan J. Loeffler, MD; Brian P. Scannell, MD; Michael J. Bosse, MD; James F. Kellam, MD; Stephen H. Sims, MD; Ronald F. Sing, DO; Eric A. Wang, MD;*  
*Carolinas Medical Center, Charlotte, North Carolina, USA*

**Background/Purpose:** Patients with pelvic ring injuries may present with hemodynamic instability necessitating pelvic angiography to identify and treat ongoing arterial hemorrhage. Pelvic angiography and embolization has been shown to be effective in controlling hemorrhage but may cause significant complications including renal failure, muscle necrosis, impotence, and the need to alter surgical treatment. Angiography has been made readily available in most trauma centers and the high level of technical skills of angiographers to perform embolizations has led to increased incidences of these patients being treated with pelvic angiography. Given the risk of complications, we reviewed our patients who presented with high-energy pelvic ring injuries to examine the appropriateness of the patient's referral for pelvic angiography and whether they underwent appropriate embolization procedures. Our hypothesis is that a high rate of disagreement exists between general surgeons, orthopaedic traumatologists, and interventional radiologists at our institution on the appropriateness of referrals for pelvic angiography and subsequent embolizations performed.

**Methods:** An IRB-approved retrospective study was performed on patients identified by the trauma registry with high-energy pelvic ring injuries presenting to a single Level I trauma center from 2004 to 2008. Of 296 identified patients, 58 (19.6%) underwent pelvic angiography. A detailed chart review was performed to determine the clinician's indications for referral to angiography, the presence of active extravasation on CT angiography, any other arterial abnormalities encountered, and the specific vessel(s) embolized. A general surgery traumatologist, three different orthopaedic traumatologists, and an interventional radiologist independently reviewed the 58 cases and determined whether they felt referral angiography was appropriate and whether the subsequent embolization performed (or not performed) was appropriate.

**Results:** There was complete agreement by all five participants in 26 of 58 cases (44.8%) that referral to angiography and the subsequent embolization performed (or not performed) was appropriate. There was disagreement in 32 of 58 cases (55.2%) as to the appropriateness of angiography referral and/or the subsequent embolization. Of these cases, there was complete agreement by all participants in 12 of 32 cases (37.5%) that angiography referral was appropriate; however, variable disagreement existed as to the appropriateness of the subsequent embolization. In 6 of 58 cases (10.3%), no embolization was performed after angiography, and there was complete agreement by all participants in these cases that this was appropriate. There were 7 of 58 cases (12.1%) in which the general surgeon and all orthopaedists disagreed with the interventional radiologist on the appropriateness of the embolization performed. There was complete agreement between the general surgeon and all orthopaedists in 36 of 58 cases (62.1%) that angiography referral was appropriate. Disagreement existed between the general surgeon and at least one of the orthopaedists on angiography referral in 22 of 58 cases (37.9%). The most frequent reasons cited for inap-

appropriate referral to angiography were stable pelvic ring injury and underresuscitated or hemodynamically stable patient. The most frequent reasons cited for inappropriate embolization were that an uninjured vessel was embolized or the embolization performed was too proximal and/or not “selective”.

**Conclusions:** There was a high rate (37.9%) of disagreement between the general surgeon and at least one of the orthopaedic traumatologists regarding what constitutes appropriate referral to pelvic angiography. There was complete agreement between all surgeons that an inappropriate embolization procedure was performed in 12.1% of cases. These data suggest that the surgeons need to remain active participants in the angiography procedure and critically develop plans with the interventional radiology team. In some cases, unnecessary or overly aggressive embolization of pelvic vessels may be avoided. Elimination of unnecessary interventions may decrease the patient’s dye load and preserve critical pelvic circulation to avoid potential serious complications.

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**Predictors of Functional Outcome in Operatively Treated Pelvic Ring Fractures***Patrick D.G. Henry, MD, FRCS(C)<sup>1</sup>; Richard J. Jenkinson, MD, FRCS(C)<sup>2</sup>;**Sebastian Rodriguez-Elizalde, MD, FRCS(C)<sup>2</sup>; David J.G. Stephen, MD, FRCS(C)<sup>2</sup>;**Hans J. Kreder, MD, FRCS(C)<sup>2</sup>;**<sup>1</sup>Division of Orthopaedics, Department of Surgery, St. Michael's Hospital, University of Toronto, Toronto Ontario, Canada;**<sup>2</sup>Division of Orthopaedics, Department of Surgery, Sunnybrook Health Sciences, University of Toronto, Toronto, Ontario, Canada*

**Purpose:** In patients with unstable pelvic ring fractures, little is known about the relationship of validated functional outcome scores with reduction accuracy and other patient factors. The purpose of this study is to evaluate this relationship.

**Methods:** 113 patients with operatively treated pelvic ring injuries at a Level I trauma center were prospectively followed for at least 1 year with data collected on demographic, injury, and radiographic parameters. Functional outcome scores were prospectively recorded using the Medical Outcomes Study Short-Form 36-item Health Survey (SF-36). A baseline preinjury score was obtained at the patients' first follow-up visit. For each patient, pre- and postoperative displacements of pelvic ring were measured on AP, inlet, and outlet radiographs using the methodology described by Tornetta and Matta. Univariate statistical comparisons of final SF-36 scores in each domain were done for age, sex, marital status, educational level, smoking status, body mass index, other major lower extremity injury (eg, pilon fracture), ongoing lawsuit, ongoing disability claim, anterior pelvic ring malreduction >1 cm, and posterior pelvic ring malreduction >5 mm. Linear multivariable models, using the SF-36 physical and mental components as outcome variables, were then used to estimate the effects of pelvic ring malreduction while controlling for the above variables and baseline SF-36 scores.

**Results:** Baseline (preinjury) SF-36 scores in each domain were significantly better than SF-36 scores at final follow-up ( $P < 0.001$ ). Baseline SF-36 scores were better than published population normative SF-36 data ( $P < 0.001$ ); however, SF-36 scores at final follow-up among the pelvic fracture patients were similar to population norms. Univariate comparisons showed a trend to worse physical function score with posterior ring malreduction ( $P = 0.08$ ) while anterior ring malreduction showed significantly worse physical function ( $P = 0.006$ ), social function ( $P = 0.015$ ), and pain ( $P = 0.036$ ) scores. Both ongoing lawsuits and disability claims predicted worse SF-36 outcomes. Other major lower extremity injuries were relatively rare and despite a large difference in outcome (physical function 49.9 vs 28.6) did not reach statistical significance ( $P = 0.069$ ). Age, sex, marital status, smoking, and body mass index were not significant. In the multivariable model of physical component SF-36 scores, anterior malreduction ( $P = 0.03$ ), ongoing disability claim ( $P = 0.001$ ), and baseline SF-36 score ( $P = 0.004$ ) were the only significant predictors of outcome. For the mental component score, anterior malreduction ( $P = 0.038$ ), ongoing lawsuit ( $P = 0.04$ ), and baseline mental component score ( $P = 0.01$ ) were the only predictive variables.

**Conclusion:** Patients with unstable pelvic ring disruptions do not return to their baseline level of function but regain similar function to age-matched peers. Obtaining a good surgical reduction of the pelvic ring, especially of the anterior component, should lead to better functional results.

See pages 97 - 144 for financial disclosure information.

• **Incidence of Posterior Wall Nonunion and Efficacy of Indomethacin Prophylaxis for Heterotopic Ossification After Operative Fixation of Acetabular Fractures: A Randomized Controlled Trial**

*Charles J. Jordan, MD; Rafael Serrano-Riera, MD; H. Claude Sagi, MD; Orthopaedic Trauma Service, Florida Orthopaedic Institute, Tampa, Florida, USA*

**Background/Purpose:** Clinically significant heterotopic ossification (HO) about the hip joint (Brooker 3 or 4) after operative fixation of an acetabular fracture is a rare, but potentially devastating, complication. Postoperative indomethacin for variable time periods has been recommended as prophylaxis, but controversy exists within the current literature as to its efficacy and safety. Additionally, the use of indomethacin prophylaxis has been reported to increase the incidence of long bone nonunion. Currently no study exists to document the effects of variable durations of indomethacin prophylaxis and its relationship to both HO and union of the posterior wall (PW). The purpose of this study is to document the efficacy of variable treatment durations with indomethacin prophylaxis for HO and its effect on union of the PW in operatively treated acetabular fractures.

**Methods:** From 2004 to 2011, 98 skeletally mature patients with an acetabular fracture requiring a posterior surgical approach for fixation were enrolled in a prospective randomized study at a single institution. All patients underwent open reduction and internal fixation through a Kocher-Langenbeck approach. Patients were randomly assigned to one of four treatment groups: (1) placebo for 6 weeks, (2) 3 days of indomethacin followed by placebo for a total of 6 weeks, (3) 1 week of indomethacin followed by 5 weeks of placebo, and (4) 6 weeks of indomethacin. Patients were followed clinically and radiographically at 1 month, 3 months, 6 months, and 1 year. At each postoperative visit, data were collected on range of motion, pain (visual analog scale [VAS] score), and radiographic presence of HO (Brooker classification). Patients underwent pelvic CT at 6 months to assess healing and for volumetric quantification of HO. All prospective data were analyzed using standard statistical methods, in order to detect differences in the abundance of HO and nonunion with varying durations of treatment, as well as differences in function and pain between groups.

**Results:** Mean age and gender distribution did not differ significantly between groups. While the overall incidence of any HO on radiographs at 1 year was greater with placebo (group 1) when compared to groups 2 and 3 ( $P = 0.046$  and  $P = 0.019$ , respectively), the amount of HO based on CT volumetric analysis and the incidence of clinically significant HO (decreased range of motion and increased VAS pain) was no different between any group at 6 months or 1 year. The overall incidence of PW nonunion was 20% for group 1 (placebo), 35% for group 2, 24% for group 3, and 50% for group 4 ( $P < 0.05$ ). While range-of-motion scores did not differ between those with and without PW nonunion, the pain VAS for those with CT-detected PW nonunion was significantly higher (3 vs 1.5,  $P = 0.044$ ).

**Conclusion:** The use of prophylactic postoperative indomethacin does not have a demonstrable effect on the volume or incidence of clinically significant HO after operatively treated acetabular fractures. Additionally, the data from this analysis suggest that the use of prophylactic postoperative indomethacin increases the incidence of symptomatic nonunion of

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the PW as assessed by CT scan and pain VAS. Based on the results of this randomized trial, we do not recommend the use of indomethacin as prophylaxis against HO after operative treatment of acetabular fractures.

**Funding:** Aided by a grant from the Orthopaedic Research and Education Foundation (OREF).

**Senior Patients With Acetabular Fractures: Surprising Epidemiology and Mortality***William W. Cross III, MD<sup>1</sup>; Milton L. "Chip" Routt Jr, MD<sup>2</sup>; Sean E. Nork, MD<sup>2</sup>;**James C. Krieg, MD<sup>2</sup>;**<sup>1</sup>Mayo Clinic, Rochester, Minnesota, USA;**<sup>2</sup>Harborview Medical Center, Seattle, Washington, USA*

**Purpose:** We sought to identify critical epidemiology and mortality information in senior patients with acetabular fractures by reviewing a recent consecutive 5-year experience at a regional Level I trauma center.

**Methods:** All patients aged 65 years or older with an acetabular fracture treated at our hospital from 2004 through 2009 were identified through an institutional fracture database. The patients' demographic data, comorbidities, mechanism of injury, associated injuries, fracture type, treatment, and mortality information were assessed. Data were analyzed with SPSS 17.0 statistical software.

**Results:** From a prospectively collected fracture database, there were 1123 acetabular fractures treated between 2004 and 2009. There were 156 patients (14%) aged 65 years or older. In these senior patients, 70% had either an associated both-column or anterior column/posterior hemitransverse (AC/PHT) fracture pattern. Not surprisingly, 82% of the patients had significant medical comorbidities, with the two most common being hypertension and diabetes. Additional primary organ system injuries occurred in 36% of these senior patients. Mechanisms of injury in this cohort included 70.5% falls and 23.1% motor vehicle accidents. 57 patients (36.5%) underwent open reduction and internal fixation using standard reduction techniques and surgical implants via two main surgical exposures: the ilioinguinal (69%) and Kocher-Langenbeck (29%). Skilled nursing facilities were used after their initial hospitalization in 77% of patients. 51 patients (33%) died within 1 year, and 75% of those were dead within 90 days of their acetabular fracture. Of the 51 who died during the study period, 84% had nonoperative treatment. For those patients treated with traction alone, there was a 79% 1-year mortality and a nearly 50% mortality rate at 90 days. Of the 105 surviving patients, 91% underwent operative treatment.

**Conclusions:** Acetabular fractures in senior patients occur uncommonly, but when they do occur there is a very high incidence of associated both-column and AC/PHT fracture patterns. Routine fixation constructs and implants can be used effectively. In these senior patients, medical comorbid conditions are common and usually impact clinical decision-making. The 90-day and 1-year mortality rates are surprisingly high, especially in those senior patients treated without surgery.

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## Predicting the Need for Arthroplasty after Acetabular Open Reduction and Internal Fixation

Rebecca Clinton, MD<sup>1</sup>; Theodore T. Manson, MD<sup>1</sup>; Renan Castillo, PhD<sup>2</sup>;  
Robert S. Sterling, MD<sup>1</sup>;

<sup>1</sup>R Adams Cowley Shock Trauma Center, Department of Orthopaedics,  
University of Maryland Medical School, Baltimore, Maryland, USA;

<sup>2</sup>Center for Injury Research & Policy, Johns Hopkins Bloomberg School of Public Health,  
Baltimore, Maryland, USA

**Purpose:** Open reduction and internal fixation (ORIF) of acetabular fracture minimizes the risk of posttraumatic arthrosis and maximizes joint preservation. However, a certain percentage of patients who undergo ORIF require later conversion to total hip arthroplasty (THA) for arthritis. We hypothesize that there is a threshold amount of joint-space narrowing predictive of subsequent THA in patients who are status postacetabular ORIF.

**Methods:** This study was performed at a Level I statewide referral center for acetabular fracture patients between 2002 and 2009. Our study group consisted of 31 acetabular fracture initially treated with ORIF that subsequently underwent THA within 3 years. We compared these patients to a control group of 31 age- and fracture pattern-matched pairs who were followed for at least 1 year after acetabular ORIF and have not required THA. Radiographs from the time of ORIF, 3 months, and 6 months were reviewed and joint space measured as a percentage of the unaffected side. All patients were treated by fellowship-trained orthopaedic trauma surgeons and in general began full weight bearing at 3 months after fracture fixation. Predictive cutoff values were evaluated using standard criteria: sensitivity, specificity, and positive predictive values (the probability that given a positive prediction of THA, the patient ends up having a THA).

**Results:** The average age of the patients in the control and study groups was 50 years. The average time from acetabular fixation to total hip arthroplasty was 406 days. The predominant fracture pattern in both groups was transverse, posterior wall. At the 3-month visit after ORIF of an acetabular fracture, if a patient had more than 20% narrowing of the joint space, this represented more than a 90% positive predictive value of future THA (95% confidence interval [CI]: 0.69, 0.98). At the 6-month visit, the correlation between joint-space narrowing and future THA was not as strong; however, if a patient had over 30% narrowing, there was an 80% positive predictive value of needing a later THA (95% CI: 0.51, 0.97).

**Conclusions:** Joint-space narrowing at the 3-month visit after ORIF is highly correlated with subsequent THA. Six-month values are less predictive of need for later THA. This is particularly useful for patient counseling regarding prognosis at the 3-month visit after acetabular fracture fixation.



**SKILLS LAB**

**ORIF Periprosthetic Fractures of the Femur (#S1)**

Moderator: *Raymond R White, MD*

Faculty: *David B. Carmack, MD; Hans-Christoph Pape, MD; J. Spence Reid, MD; Nirmal C. Tejwani, MD and Lawrence X. Webb, MD*

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## CASE PRESENTATIONS

### **Proximal Humerus Fractures**

Moderator: *Michael J Gardner, MD*

Faculty: *Samir Mehta, MD and Andrew H. Schmidt, MD*

### **Distal Femoral Fractures**

Moderator: *Darin Freiss, MD*

Faculty: *Amer J. Mirza, MD; David C. Templeman, MD and Heather H. Vallier, MD*

### **Post-traumatic Infection**

Moderator: *Utku Kandemir, MD*

Faculty: *Animesh Agarwal, MD and Bruce H. Ziran, MD*

### **Management of Physeal Fractures Around the Knee and Ankle**

Moderator: *David A. Podeszwa, MD*

Faculty: *Christina A. Ho, MD; Anthony I. Riccio, MD and Robert L. Wimberly, MD*

### **Scapula Fracture Injuries and Treatment**

Moderator: *William T. Obrebskey, MD*

Faculty: *Peter A. Cole, MD and Clifford B. Jones, MD*

## NOTES

**MINI SYMPOSIA**

**Two Minutes / Two Slides: Focus on the Pelvis and Acetabulum**

Moderator: *Pierre Guy, MD, MBA*

Faculty: *Kelly A. Lefaiore, MD; Christopher G. Moran, MD; Jason W. Nascone, MD  
H. Claude Sagi, MD; Adam J. Starr, MD and David J. Stephen, MD*

**Preoperative Nightmares in Orthopaedic Trauma: Deal with It**

Moderator: *John T. Gorczyca, MD*

Faculty: *Michael A. Miranda, MD; Kevin J. Pugh, MD;  
Michael S. Sirkin, MD and Jeffrey M. Smith, MD*

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## How High Can You Go: Retrograde Nailing of Proximal Femur Fractures

Lisa K. Cannada, MD; Kevin M. Kuhn, MD; J. Tracy Watson, MD;

Southeast Fracture Consortium;

Saint Louis University Hospital, Saint Louis, Missouri, USA

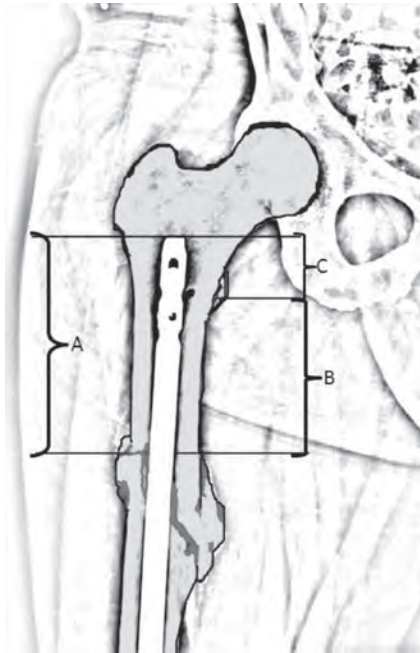
**Purpose:** Retrograde nailing (RGN) has been used for select indications in femoral shaft fractures. However, fractures in the proximal one-third have been considered “off limits” for RGN with increased complication rates anticipated. There are no data supporting recommendations on how proximal is too proximal for RGN. We describe a proximal segment capture ratio. It is our premise that a smaller capture ratio represents a very proximal fracture with less nail capture and thus will result in a higher rate of malunion/nonunion.

**Methods:** At six Level I trauma centers, skeletally mature patients with femur fractures within the proximal one-third of the femur treated with retrograde intramedullary nails were included. Clinical records were reviewed and data obtained and compared with regard to demographic information, comorbidities, associated injuries, operative details, time to union, time to full weight bearing, radiographic outcomes, complications, and need for secondary procedures. To evaluate RGN of proximal fractures, we describe a proximal segment capture ratio (PSCR). This ratio is determined by the length from the top of nail to fracture location (A) and the distance from the lesser trochanter (LT) to fracture site (B). The PSCR is a ratio of the amount of nail above the lesser trochanter (C) (see figure). Statistical analysis was completed using descriptive statistics,  $\chi^2$  for nominal variables, and *t* tests for continuous variables.

**Results:** There were 107 patients (59 males, 48 females) with RGN of proximal one-third femur fractures with adequate radiographic and clinical follow-up defined as radiographic union and/or full weight bearing. The average age of the patients was 33 years (range, 17-71) with an average ISS of 19 (range, 9-75). The average tip of nail to fracture measure (A) was 12 cm (range, 2.3-19). The average distance from the LT to fracture site (B) was 8 cm (range, 0.7-12). The average PSCR (C/A) ratio was 0.35 (range, 0.04-0.89). The average time to union increased in those fractures with comminution. The average time to full weight bearing was 10 weeks with an average follow up of 44.4 weeks. There were 2 nonunions and 3 malunions. Nine patients required secondary procedures: 4 dynamizations and 1 revision to a plate with bone graft, all of which went on to heal; 1 wound débridement, 1 shortening procedure, and 2 procedures for heterotopic ossification removal. There was no significant difference between a PSCR ratio of 0.3 or less and need for secondary procedures or time to full weight bearing ( $P > 0.05$ ). The occurrence of malunion was increased with OTA C-type fractures and overall time to union was increased ( $P < 0.05$ ).

**Conclusion:** We describe a proximal segment capture ratio to help determine a cut-off distance whereby the amount of nail above the fracture versus distance of the fracture below the LT could define indications for proximal femoral shaft RGN. A smaller ratio could indicate a less stable construct and potentially a higher rate of nonunion/malunion. In our study, a smaller ( $< 0.3$ ) PSCR was not associated with increased number of secondary procedures, nonunion, or malunion. A higher OTA classification (increased comminution) was predictive of malunion and increased time to union. Fractures with increased comminution, despite an

adequate nail capture ratio, trended toward varus malreductions and subsequent malunion. In this study, the proximity of the fracture to the LT alone did not affect results. Using those guidelines, RGN is safe and effective for the treatment of supraisthmal femur fractures.



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## Gait Analysis After Retrograde and Trochanteric Entry Intramedullary Nail Fixation of Femoral Shaft Fractures

*Kellen L. Huston, MD; J. Tracy Watson, MD; Lisa K. Cannada, MD;*

*Saint Louis University Department of Orthopaedic Surgery, Saint Louis, Missouri, USA*

**Purpose:** The starting point for femoral nailing continues to be the focus of debate. Current dogma suggests that retrograde nailing causes knee pain and dysfunction. Antegrade nailing has been reported to alter abductor mechanics. However, the effects of retrograde nailing on gait have not been thoroughly determined. The purpose of this study was to evaluate entry portal influence on gait and stair climbing following retrograde (RN) and trochanteric entry nailing (TN).

**Methods:** IRB-approved inclusion criteria included adult patients with isolated femur fractures treated with intramedullary nails who were clinically and radiographically healed. Patients required at least 6 months of device-free ambulation following fracture union. Demographic and fracture data were collected on the participating subjects. Subjects also completed a Musculoskeletal Function Assessment (MFA) questionnaire, walked on a treadmill, and demonstrated ascending/descending stair climbing. Digital video gait analysis of all subjects was completed using surface markers and Dartfish model software. Statistical analysis was completed using descriptive methods to calculate mean and standard deviation. Frequency tables were used for calculation of categorical data significance and Mann Whitney *U* tests for nominal data sets.

**Results:** 16 patients underwent gait analysis: 8 TN and 8 RN. The average age of the patients was 29 years (range, 22-44) in the TN group and 32 years (range, 22-45) in the RN group. The average length of time from injury to participation in the study was 24 months (range, 10-41). There was no significant difference between the groups on the MFA questionnaire ( $P = 0.127$ ). No differences were noted in subjective measures of gait or stair climbing. When evaluating the kinematics of the knee via gait analysis, no significant difference was demonstrated between the normal or affected knee at heel-strike or at toe-off. When comparing the hip kinematics between entry portal groups, TN patients demonstrated significant differences on the normal limb at toe-off ( $P < 0.05$ ) and on the affected limb at heel-strike ( $P < 0.05$ ) consistent with abductor alteration.

**Conclusion:** Previous studies have shown significant effects from antegrade femoral nailing in terms of hip abductor function and lower extremity biomechanics. No such studies exist looking at retrograde femoral nailing or comparing the two methods. Our study demonstrated an effect on hip function at toe-off of the normal and heel-strike of the affected leg in the TN group that is not seen in the RN. Although RN does involve the knee joint for proper entry portal placement, it does not have any significant affect on gait function. In conclusion, trochanteric or retrograde nailing may lead to some of residual discomfort to the patient but TN has the potential to cause a mechanical disturbance in gait. Patients treated with RN did not demonstrate gait disturbances.

### **Δ Radiographic Outcomes of Closed Diaphyseal Femur Fractures Treated With the SIGN Nail**

*Sasha P. Carsen, MD; Si-Hyeong Park, MD; David A. Simon, MD; Robert J. Feibel, MD; University of Ottawa/The Ottawa Hospital, Ottawa, Ontario, Canada*

**Purpose:** The burden of orthopaedic trauma in the developing world is significant and disproportionate, both in health and economic terms. The Surgical Implant Generation Network (SIGN) has developed and made available through donation to surgeons in resource-limited settings an intramedullary prosthesis for use in the treatment of fractures of the femur and the tibia, with the prosthesis and all necessary tools donated. Despite the great clinical success of the SIGN Nail, with more than 70,000 surgeries performed, there has been very little research examining outcomes. Our primary purpose was to examine the postoperative radiographs of closed diaphyseal femur fractures treated with the SIGN Nail to assess for alignment, and to evaluate variables for risk of malalignment. Our secondary goal was to assess the functionality and robustness of data in the SIGN database.

**Methods:** A retrospective review of SIGN's prospectively populated database was performed for patients treated with the standard SIGN Nail for a diaphyseal femur fracture, which at the time of the study totaled 32,362. Exclusion criteria included open fractures and those without postoperative radiographs. A random number generator was used to randomly select 500 cases for analysis, and the following information was recorded: location of the fracture within the diaphysis, fracture classification (AO/OTA classification), degree of fragmentation (Winquist classification), time from injury to surgery, and patient demographics. Measurements of alignment were then made based on the AP and lateral radiographs, with malalignment defined conservatively as deformity in either the sagittal or coronal plane  $>5^\circ$ . Measurements were made manually using on-screen protractor software (Screen Protractor, by Iconico), and intra- and interobserver reliability assessed. The quality of radiographs for each case was graded based on adequacy for visualization of the fracture and the femur, and the ability to measure alignment in orthogonal planes.

**Results:** The incidence of malalignment in postoperative radiographs was found to be 10.3%, with malalignment defined as deformity in either the sagittal or coronal plane  $>5^\circ$ . 92% of reviewed radiographs were of acceptable or good quality. Fracture location in the proximal or distal diaphysis was strongly correlated to risk of mal-alignment ( $P < 0.01$ ). Time from injury to surgery of  $>4$  weeks was also strongly correlated to risk of malalignment ( $P < 0.01$ ). Degree of fragmentation was found to be an independent predictor of angulation and malalignment ( $P = 0.07$ ).

**Conclusion:** The incidence of malalignment in femoral fractures treated with the SIGN Nail closely approximated the incidence previously reported in the literature for a North American trauma center. This is an encouraging finding, and provides support for the continued and expanded use of the SIGN prosthesis throughout the developing world. Risk factors for malalignment include: fractures of the proximal or distal diaphysis; fractures with increased fragmentation; and, of note, fractures waiting  $>4$  weeks for surgery. In addition, the SIGN database, which is populated by data submitted by SIGN surgeons around the world, was found to be a satisfactory resource for the purpose of retrospective research.

Δ OTA Grant

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### **Clinical and Functional Outcomes in Patients Who Sustained Bisphosphonate-Associated Complete Femur Fractures**

*Kenneth A. Egol, MD; Ji Hae Park, BS; Zehava Sadka Rosenberg, MD; Valerie H. Peck, MD; Nirmal C. Tejwani, MD; NYU Hospital for Joint Diseases, New York, New York, USA*

**Purpose:** Recent literature provides substantial evidence that long-term bisphosphonate therapy is associated with atypical subtrochanteric and diaphyseal femur fractures in a small subgroup of patients. Increasing evidence also suggests that incomplete femur fractures may progress to complete fractures without surgical intervention. The purpose of this study is to evaluate the ultimate outcomes of patients, treated at a single institution, with complete atypical femur fractures associated with long-term bisphosphonate use.

**Methods:** Between 2004 and 2011, 68 patients with 101 atypical femur fractures associated with long-term bisphosphonate use were identified and enrolled in this IRB-approved study. Fractures were classified as incomplete or complete. Patient demographics, initial radiographic diagnosis, treatment modality, time to healing, and self-reported functional status were retrospectively documented. Patients were contacted via telephone at a mean 30 months from date of fracture presentation (range, 6-85 months) to complete the Short Musculoskeletal Function Assessment (SMFA). The SMFA was used to gauge baseline as well as postintervention functional status. Patients who had not yet reached the 6-month follow-up interval and those who could not be contacted for follow-up questions were excluded from functional analysis. Data were analyzed by Student *t*-test and Fisher exact test.

**Results:** Patients had been treated with bisphosphonates for an average of 8.5 years (range, 2-20) prior to presentation. The final cohort consisted of 34 patients with 42 complete atypical femur fractures subsequent to low-energy trauma who underwent surgery. Patients reported a mean of 6 months of pain prior to injury (range, 1-8 months). 67% of surgically treated complete fractures became pain-free and 93% were radiographically healed by 12 months. 65% of patients who underwent intramedullary nailing reported a functional return to baseline within 1 year. Patients who reported significant functional limitations at latest follow-up listed pain and apprehension as the major causes of their limitation.

**Conclusion:** Patients who sustain bisphosphonate-associated complete femur fractures and are treated surgically can expect to return to baseline within 1 year and should be counseled as such. Functional outcomes support radiographic findings and clinical signs of healing. Patients should be advised of the potential risk of sustaining a complete fracture and of the benefits of preventative surgical treatment.



## Why are Reported Nonunion Rates After Locked Plate Fixation of Distal Femur Fractures so Variable? A Multicenter Retrospective Study of 284 Fractures

Edward K. Rodriguez, MD, PhD<sup>1</sup>; Michael J. Weaver, MD<sup>2</sup>; Lindsay M. Herder, BA<sup>1</sup>; Jordan H. Morgan, BS<sup>2,3</sup>; David Zurakowski, MD<sup>4</sup>; Paul T. Appleton, MD<sup>1</sup>; Mark S. Vrahas, MD<sup>2,3</sup>;

<sup>1</sup>Beth Israel Deaconess Medical Center, Department of Orthopaedics, Boston, Massachusetts, USA;

<sup>2</sup>Brigham and Women's Hospital, Department of Orthopaedics, Boston, Massachusetts, USA;

<sup>3</sup>Massachusetts General Hospital, Department of Orthopaedics, Boston, Massachusetts, USA;

<sup>4</sup>Children's Hospital, Boston, Massachusetts, USA

**Background/Purpose:** Reported initial success rates after lateral locked plating (LLP) of distal femur fractures have given way to more concerning outcomes with reported nonunion rates now ranging from 0% to 21%. Reported factors associated with nonunion include comorbidities such as obesity, age, and diabetes, as well as technical factors such as plate length and screw density of constructs. Our goal was to examine variation in institutional nonunion rates at three Level I trauma centers treating a similar patient population in order to define a set of patient characteristics that identify nonunion risk and to determine if nonunion rates are related to the management approach. We hypothesized that institutions with a more aggressive approach to nonunion management based on radiographic findings and patient symptoms would have higher nonunion rates and shorter times to intervention than those where nonunion is primarily managed only after hardware failure.

**Methods:** A retrospective review was conducted of all distal femoral fractures treated with LLP at the three institutions (A, B, C) comprising our Combined Trauma Service (August 2004–December 2010). Nonunion was defined as the need for a secondary procedure to manage poor healing based on individual surgeon criteria (hardware failure, radiographic findings, and/or patient symptoms). 284 fractures met inclusion criteria and each patient's chart and radiographs was reviewed to extract age, gender, medical comorbidities (obesity, diabetes, tobacco use, steroid usage, dialysis), and injury characteristics (AO fracture type, open vs closed, mechanism of injury, periprosthetic). Multivariate analysis was performed using the Cox regression model.

**Results:** 29 of the 284 fractures analyzed went on to nonunion (10.2%). Only obesity, diabetes, and an open fracture were significant independent risk factors. 38% of patients with nonunion had diabetes compared with 23% of patients in the healed group. 57% of patients with nonunion were obese compared with 37% of patients in the healed group. 23% of patients with open fractures went on to nonunion. Institution A had 14.1% of all nonunions, B had 8.8%, and C had 8.1%. While  $\chi^2$  testing suggested no differences in nonunion rates between the institutions, the time to intervention for nonunions varied inversely with nonunion rates. Institution A intervened on average at  $9 \pm 4$  months, institution B at  $11 \pm 7$  months, and C at  $20 \pm 10$  months. Institution C had a significantly longer time to intervention for nonunion than A ( $P = 0.02$ ) and B ( $P = 0.04$ ).

**Conclusions:** Obesity, diabetes, and an open fracture are all predictors of nonunion in distal femoral fractures treated with LLP despite differences in how surgeons define and manage

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nonunion. The institutional difference in nonunion rates, and perhaps in the literature, may be explained in part by individual surgeon approaches to the management of the nonunion patient. Without a consistent definition of nonunion, comparisons between institutions and surgeons are difficult.

## **A Comparison of More and Less Aggressive Bone Débridement Protocols for the Treatment of Open Supracondylar Femur Fractures**

*William M. Ricci, MD<sup>1</sup>; Cory A. Collinge, MD<sup>2</sup>; Philipp N. Streubel, MD<sup>1</sup>;*

*Christopher M. McAndrew, MD<sup>1</sup>; Michael J. Gardner, MD<sup>1</sup>;*

*<sup>1</sup>Washington University School of Medicine, Saint Louis, Missouri, USA;*

*<sup>2</sup>Harris Methodist Fort Worth Hospital, Fort Worth, Texas, USA*

**Background/Purpose:** Modern treatment of high-energy open fractures calls for one or more initial débridements followed by definitive fixation. Aggressive débridement of devitalized or marginally vital bone theoretically minimizes infection risk but may lead to segmental bone defects that require staged bone grafting. Less aggressive bone débridement may increase the risk of infection, but leaves behind more bone for potential healing. This study compared results of aggressive and nonaggressive débridement protocols for the treatment of high-energy open supracondylar femur fractures with regard to deep infection, healing after the primary procedure, and requirement for secondary bone-grafting procedures.

**Methods:** Surgeons at two different Level I trauma centers had different débridement protocols for open supracondylar femur fractures. One center utilized a More Aggressive protocol that included removal of all devitalized bone and placement of antibiotic cement spacers to fill large segmental defects. The other center used a Less Aggressive protocol that included débridement of only grossly contaminated bone with retention of other bone fragments and no use of antibiotic cement spacers. Other aspects of treatment protocols at the two centers were similar: definitive fixation was with locked plates in all cases; IV antibiotics were used until definitive wound closure; and weight bearing was advanced upon clinical and radiographic evidence of fracture healing. 17 consecutive patients treated at the More Aggressive protocol center (average age, 50 years; range, 30-78) and 12 at the Less Aggressive protocol center (average age, 53 years; range, 27-80) were retrospectively reviewed. Demographics were similar ( $P > 0.05$ ) between included patients at each center with regard to age, gender, frequency of open and closed fractures, open fracture grade, mechanism, and smoking. Patients at the More Aggressive center were more often diabetic and had higher body mass index ( $P > 0.05$ ).

**Results:** Cement spacers to fill segmental defects were used more often after More Aggressive débridement (47% vs 0%) and more patients had a plan for staged bone grafting after More Aggressive débridement (71% vs 8%) ( $P < 0.006$ ). Healing after the index fixation procedure occurred more often after Less Aggressive débridement (92% vs 35%) ( $P < 0.003$ ). There was no difference in infection rate between the two protocols: 25% with the Less Aggressive protocol; and 18% with the More Aggressive protocol ( $P = 0.63$ ). All patients in both groups eventually healed and were without evidence of infection at an average of 1.8 years of follow-up.

**Conclusions:** The degree to which bone should be débrided after open fracture is a matter of surgeon judgment. The theoretic tradeoff between infection risk and osseous healing potential, based on the results of the current study, seems to favor less aggressive débridement for the initial treatment of high-energy, high-grade, open supracondylar femur fractures treated with locked plating. Leaving devitalized bone in the face of open fracture may be considered heresy, but may also provide better results than aggressive débridement.

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**Compartment Pressure Monitoring for Acute Compartment Syndrome***Margaret M. McQueen, MD; Andrew D. Duckworth, MBChB, BSc (Hons);**Stuart A. Aitken; Charles M. Court-Brown, MD;**Edinburgh Orthopaedic Trauma Unit, Royal Infirmary of Edinburgh,**Edinburgh, Scotland, United Kingdom*

**Purpose:** A delay in the diagnosis of acute compartment syndrome (ACS) has been documented to predict a poor outcome for the patient. A means of predicting the development of ACS could lead to an earlier diagnosis. The first aim of our study was to identify the risk factors associated with the development of ACS. The second aim was to document the sensitivity and specificity of continuous intracompartmental pressure (ICP) monitoring for the diagnosis of ACS.

**Methods:** From our prospective trauma database we identified all patients who sustained an acute tibial diaphyseal fracture over a 13-year period. A retrospective analysis of 1407 patients was performed to record and analyze the fracture classification, open fractures, treatment, development of ACS, and other patient demographics including smoking, occupation, and socioeconomic deprivation. A diagnosis of ACS was made using clinical signs, with compartment pressure monitoring or a combination of the two. Statistical analysis used univariate and multiple logistic regression analysis. To determine the diagnostic performance characteristics of ICP monitoring we identified all patients who sustained a tibial diaphyseal fracture over a 10-year period. A retrospective analysis of 1184 patients was performed to record and analyze the documented use of continuous ICP monitoring and the need for fasciotomy. A diagnosis of ACS was made if there was escape of muscles at fasciotomy, color change in the muscles or muscle necrosis intraoperatively, or if it was not possible to perform primary closure at 48 hours postfasciotomy. The absence of ACS was confirmed by the absence of neurologic abnormality or contracture at final follow-up.

**Results:** There were 1388 patients in the primary analysis, with a mean age of 39 years (range, 12-98), and 957 (69%) were male. A total of 160 (11.5%) patients were diagnosed with ACS. Age was strongly predictive for the development of ACS ( $P < 0.001$ ), with the highest prevalence between 12 and 19 years and 20 and 29 years. Male gender, blue collar occupation, sporting injury, fracture classification, and treatment with intramedullary nails also showed an association with the occurrence of ACS (all  $P < 0.05$ ). Occupation ( $P = 0.01$ ) and implant type ( $P = 0.004$ ) were the only factors that remained significant after adjusting for age.

Following review of 1184 patient records, 979 monitored patients were identified, of whom 850 fit the inclusion criteria with a mean age of 38 years (range, 12-94), and 598 (70.4%) were male ( $P < 0.001$ ). A total of 152 (17.9%) patients underwent fasciotomy for ACS, of whom 141 were considered to have ACS (true positives) and 6 not (false positives). There were five cases where fasciotomy was performed despite a normal monitor reading, with subsequent operative findings consistent with ACS (false negatives). Of the 698 (82.1%) patients who did not have a fasciotomy, 689 had no evidence of any late sequelae of ACS (true negatives) at a mean follow-up of 14 months. Based on our data, we have found the sensitivity of ICP monitoring for suspected ACS to be 94%, with a specificity of 98%, a positive predictive value of 93%, and a negative predictive value of 99%.

See pages 97 - 144 for financial disclosure information.

**Conclusions:** This is the largest series documenting the risk factors predictive for the development of ACS following an acute tibial diaphyseal fracture, with youth the strongest predictor. This study is also the first to document the high sensitivity and specificity of continuous ICP monitoring for the diagnosis of ACS following tibial diaphyseal fracture. Based on our findings and the current available literature, we recommend that all patients at risk of ACS should undergo continuous ICP monitoring, with a beneficial reduction in the delay to diagnosis and urgent fasciotomy possible.

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### **Radiographic Predictors of Compartment Syndrome after Tibial Fracture**

*Chris Allmon, MD; Ebrahim Paryavi, MD, MPH; Andrew Dubina; Robert V. O'Toole, MD; R Adams Cowley Shock Trauma Center, Department of Orthopaedics, University of Maryland Medical School, Baltimore, Maryland, USA*

**Purpose:** Compartment syndrome (CS) is a potentially devastating injury that has been associated with tibial fractures. Little data exist regarding the radiographic predictors of CS. Our hypothesis was that radiographic measures of the fracture would be associated with the development of CS.

**Methods:** Our study group was a consecutive series of patients with tibial fractures with CS (n = 40) and without CS (n = 341) at a single Level I trauma center. Radiographs were reviewed and the following parameters were recorded: fracture classification according to the AO/OTA system and the Schatzker system for plateaus, proximal extent of fracture, distal extent of fracture, location of center of fracture, length of fracture, and location of fracture. Bivariate logistic regression was used to determine the relationship between the radiographic parameters and likelihood of compartment syndrome. Medical records were then reviewed for evidence of CS diagnosed by an attending orthopaedic surgeon and treated by emergent fasciotomy.

**Results:** Consistent with existing dogma, CS was most likely with more proximal fractures such as those in the second decile of the tibia, occurring at a rate of 38%. What has not been previously reported is that the rate of CS rose monotonically according to length of the fracture line, peaking at 38% when the fracture comprised between 40% and 60% of the total tibial length. Schatzker VI fractures developed CS at a rate of 27%, whereas only 4% of 25 Schatzker IV medial plateau fracture dislocations developed CS. Further analysis demonstrated that odds of CS increased by a factor of 1.91 (95% confidence interval [CI] 1.46 to 2.49) for every 10% of the total tibial length the fracture occupied. The odds of CS decreased by 27% (95% CI 16%, 37%), 23% (95% CI 32%, 13%), and 18% (95% CI 27%, 9%) for every 10% of the total tibial length the proximal fracture extent, fracture middle, and distal fracture extent were away from the proximal end of the tibia, respectively. In comparison to all plateau fractures, Schatzker VI plateaus have an odds ratio of CS of 3.98 (95% CI 1.68, 9.45), whereas in contrast to previous case series we did not observe Schatzker IV to have a statistically significant association with CS: odds ratio is 0.17 (95% CI 0.02, 1.29).

**Conclusion:** To our knowledge this is the largest series to rigorously examine radiographic predictors of CS. In keeping with expectations, we observed that Schatzker VI plateau fractures and more proximal fractures are more likely to develop CS. However, to our knowledge this is the first study to propose a powerful new predictor of CS, the total length of the fracture. This parameter may be of use to clinicians as they evaluate patients for their risk of CS and in helping to diagnose patients with CS.

## **NIRS Versus Direct Pressure Monitoring of Acute Compartment Syndrome in a Porcine Model**

*Curtis J. Cathcart, DVM; Michael S. Shuler, MD; Lt Col Brett A. Freedman, MD; Lisa R. Reynolds, BS, RVT; Ashley L. Cole, MPH; Thomas E. Whitesides, Jr., MD; Emily K. Smith, MPH; Steven C. Budsberg, DVM, DAVCS; University of Georgia, Athens, Georgia, USA*

**Purpose:** Acute compartment syndrome (ACS) can have devastating sequelae if missed or if treatment is delayed. Near-infrared spectroscopy (NIRS) has been proposed for continual, noninvasive monitoring of traumatized extremities. This study sought to correlate NIRS and the tibial intracompartmental perfusion pressure (TIPP) in a porcine model of ACS.

**Methods:** The study consisted of Landrace swine divided into two groups: control (N = 16) and acute trauma (N = 15). All pigs were maintained on isoflurane with positive pressure ventilation, and supportive care. Pigs were positioned in dorsal recumbency. A median saphenous artery was catheterized for direct arterial pressure management. Each tibia was surgically scrubbed and an NIRS sensor (Nonin) placed over the craniolateral muscle compartment. On the test leg of all pigs, 2 18-gauge needles were centered on each side of the sensor, angled 20° toward the center. Proximal and distal needles were used for 5% albumin infusion to manually elevate tibial intracompartmental pressures (TICP). Cranial and caudal needles were used for direct pressure transducer measurement of TICP by averaging the values. An 18-gauge needle on the lateral aspect of the control leg sensor measured TICP via direct pressure transducer. Continual time synchronized measures of systolic (SAP), diastolic, and mean arterial pressures (MAP); pulse rate; respiratory rate; systemic pulse oximetry; body temperature; TICP; and NIRS from each leg were collected. For the control group, transducers were zeroed and TIPP of the test leg was incrementally increased by albumin infusion. Measurements were taken at baseline for 10 minutes, TIPP = 40, 30, 20, and 10 mmHg for 5 minutes each, TIPP = 0 mmHg for 10 minutes, TIPP equal to MAP for 10 minutes, SAP for 10 minutes, and SAP + 10 mmHg for 10 minutes. Fasciotomies were then performed and measurements taken for 10 additional minutes. All pigs were euthanized at the end of the experiment. For the acute trauma group, instrumentation was marked and removed from the test leg after the 10-min baseline period. The limb was stabilized and trauma induced by dropping a 2-kg weight 30 times down a 100-cm high cylindrical tube on the craniolateral compartment. Instrumentation was replaced and a 45-min equilibration period observed before the infusion protocol was performed as described above. The contralateral (nontraumatized) leg was used as an internal control. For each group, a repeated-measures analysis of variance model, including factors for group, time, and group by time interaction, tested for differences in TICP, TIPP, and NIRS values. All tests were two-sided with  $\alpha < 0.05$  considered significant. Pearson's correlations were calculated between TICP and NIRS, and TIPP and NIRS.

**Results:** Both models created consistent, reproducible increases in TICP and decreases in TIPP. Significant increases in TICP between test and control limbs were found at all time points except TIPP = 40 mmHg and 5 and 10 minutes following fasciotomies. NIRS was able to detect significant changes in tissue oxygenation at all the same time points. All TICP of

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the test leg increased significantly from baseline except for 10 minutes following fasciotomy. Once TIPP reached 20 mmHg, NIRS decreased significantly from baseline and did not return to baseline levels until 5 and 10 minutes after fasciotomies. NIRS was able to detect decreased oxygenation at every TIPP decrease and subsequent increase following fasciotomies. TIPP was significantly different than baseline at all time points until 5 minutes after fasciotomies. Similar TIPP and TICP were observed among nontraumatized and traumatized test limbs, with the exception that traumatized test limb NIRS were significantly lower immediately after the trauma event. Significant negative correlations of TICP and NIRS (trauma:  $r = 0.70$ ,  $P < 0.0001$ ; controls:  $r = 0.79$ ,  $P < 0.0001$ ) and positive correlations of TIPP and NIRS (trauma:  $r = 0.70$ ,  $P < 0.0001$ ; controls:  $r = 0.80$ ,  $P < 0.0001$ ) were observed.

**Conclusions:** NIRS provided a reliable, sensitive measure correlating to both an increase and decrease in TICP and TIPP, respectively, in this model. The addition of acute trauma to the model did not alter the correlations of NIRS values with TICP and TIPP. Despite 70 minutes of TIPP that were significantly below baseline, oxygenation returned to normal after fasciotomy, suggesting no permanent muscle damage. Further research is needed to determine at what NIRS reading a fasciotomy may be indicated to prevent permanent tissue damage.



## Complications Following Tension Band Fixation of Patellar Fractures With Cannulated Screws Versus Kirschner Wires

C. Max Hoshino, MD<sup>1</sup>; Wesley Huy Tran, MD, JD<sup>1</sup>; John V. Tiberi, MD<sup>1</sup>;

Mary Helen Black, PhD<sup>2</sup>; Bonnie H. Li, MS<sup>2</sup>; Stuart M. Gold, MD<sup>1</sup>; Ronald A. Navarro, MD<sup>2</sup>;

<sup>1</sup>Department of Orthopaedic Surgery, Harbor-UCLA Medical Center, Torrance, California, USA;

<sup>2</sup>Department of Orthopaedic Surgery, Kaiser Permanente South Bay Medical Center, Harbor City, California, USA

**Purpose:** Displaced patellar fractures are commonly stabilized with a modified anterior tension band construct. The goal of the current study is to compare the incidence of complications after tension band fixation of the patella with Kirschner wires (K-wires) versus screws.

**Methods:** We performed a retrospective cohort study of consecutive operatively treated patella fractures. Patients were divided into two cohorts: fractures fixed using K-wires and fractures fixed using screws. The primary outcome measure was revision surgery for early loss of fixation. Secondary outcomes that were evaluated include postoperative infection and the need for hardware removal due to hardware irritation.

**Results:** 448 patellar fractures were studied. K-wires were used to fix 315 (70%), and screws were used to fix 133 (30%). The incidence of fixation failure was 3.5% in the K-wire group and 7.5% in the screw group ( $P = 0.065$ ). A postoperative infection occurred in 4.4% of patients in the K-wire group and 1.5% of patients in the screw group ( $P = 0.17$ ). 116 patients (37%) in the K-wire group and 30 (23%) in the screw group underwent elective hardware removal ( $P = 0.003$ ). After adjusting for confounding variables, a trend toward increased incidence of fixation failure with screws compared to K-wires was still present ( $P = 0.083$ ). Patients treated with K-wires were twice as likely to undergo hardware removal compared to those treated with screws ( $P = 0.002$ ). The median follow-up was 2.8 years in the K-wire group and 2.5 years in the screw group.

**Conclusion:** Serious complications are rare following treatment of patellar fractures with modified tension band using either K-wires or cannulated screws. In both groups the rate of fixation failure was low, but a trend was present toward fewer fixation failures with K-wires compared to screws. With contemporary perioperative measures, the rate of postoperative infection was low. Symptomatic hardware, the most common complication observed, was twice as frequent in patients treated with K-wires. These findings provide a foundation for future prospective, randomized studies, to confirm the observations.

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### **The Incidence of Meniscal Tears Requiring Repair in Tibial Plateau Fractures: A Review of 670 Patients**

*Daniel L. Stahl, MD; Rafael Serrano-Riera, MD; Bradley Deafenbaugh, MD; Roy Sanders, MD; H. Claude Sagi, MD; Florida Orthopedic Institute, Tampa, Florida, USA*

**Background/Purpose:** Based on publications using preoperative MRI studies, the incidence of meniscal tears in patients with tibial plateau fractures has been reported to vary from 40% to 80%. The purposes of this study are to determine (1) the incidence of meniscal tears noted intraoperatively that required repair, and (2) if a correlation exists between type of plateau fracture (Schatzker and OTA classification) and incidence of meniscal tear.

**Methods:** Tibial plateau fractures in skeletally mature patients treated operatively from 2002 to 2011 were included in the study. All operative notes, initial history and physicals, and radiographs were retrospectively reviewed to determine type of tibial plateau fracture (Schatzker and OTA classification), mechanism of injury, and intraoperative detection of meniscal tear. Patients were excluded if there was no mention of submeniscal arthrotomy or if surgical stabilization was performed percutaneously. Statistical analysis was performed using  $\chi^2$  analysis and Fisher exact testing to determine the overall incidence of meniscal tears and any correlation with meniscal tear and type of tibial plateau fracture.

**Results:** 670 patients were included in the final analysis. Meniscal tears were found in 207 patients, making the overall incidence of meniscal tears detected intraoperatively 31%. Schatzker II (OTA 41-B3) tibial plateau fractures had a significantly higher incidence of meniscal tears compared to all other Schatzker classifications ( $P < 0.001$ ). The incidence of meniscal tears associated with each Schatzker fracture pattern was: 12% for type I fractures, 45% for type II fractures, 17% for type III fractures, 15% for type IV, 24% for type V, and 30% for type VI. For the meniscal tears associated with the Schatzker II fractures ( $n = 203$ ), peripheral tears were most common (53% of tears). For the other fracture patterns, the type of meniscal injury was evenly distributed between peripheral, radial, and bucket-handle tear.

**Conclusions:** This is the largest intraoperative study performed to date determining the incidence of meniscal tears in tibial plateau fractures. Our results show a much lower incidence (30%) of meniscal tears detected intraoperatively that require repair than previously reported in the literature with studies utilizing preoperative MRI (up to 90%). Meniscal tears needing repair associated with tibial plateau fractures are most commonly peripheral rim tears seen in the Schatzker II variant.

## Complications of High-Energy Bicondylar Tibial Plateau Fractures Treated With Dual Plating Through Two Incisions

Michael R. Ruffolo, MD; Harvey E. Montijo; Franklin K. Gettys; Rachel B. Seymour; Madhav A. Karunakar, MD; Carolinas Medical Center, Charlotte, North Carolina, USA

**Purpose:** The purpose of this study is to characterize the rate of complications following operative fixation of Schatzker 6 (OTA 41-C3) tibial plateau fractures and to evaluate the contribution of common risk factors.

**Methods:** An IRB-approved retrospective review was performed on 246 consecutive patients treated for bicondylar tibial plateau fractures at a single institution over a 6-year period. 138 patients with 140 fractures met our inclusion criteria of OTA 41-C3 classification, treated by open reduction and internal fixation using a dual plate construct and two incisions, and follow-up until union or 1 year. Injuries were classified as open or closed and by the presence of compartment syndrome. Demographic data including age, gender, body mass index (BMI), mechanism of injury, tobacco use, and time to definitive fixation were recorded. BMI was analyzed as a dichotomous variable using the National Institutes of Health definition for obesity class II (BMI >35). The primary outcomes evaluated were nonunion and deep infection. Deep infection was defined as irrigation and débridement requiring return to the operating room and a positive deep wound culture. Nonunion was defined as revision fixation for insufficient healing at a minimum of 6 months after the index procedure.

**Results:** 16 patients (11.6%) had open fractures, and 25 (18.1%) had compartment syndrome. The average follow-up was 64.5 weeks (range, 12-303 weeks). The average time from injury to definitive fixation was 12.5 days (range, 1-35 days). The overall major complication rate was 27.9%: 23.6% deep infection and 10.0% nonunion. Open fractures were associated with a higher rate of infection, 43.8% compared to 21.0% for closed injuries ( $P = 0.02$ ), and a higher, but nonsignificant, increased risk of nonunion, 18.8% compared to 8.9% closed ( $P = 0.11$ ). Patients with a BMI >35 had a significantly higher nonunion rate: 21.1% compared to 6% in those with a BMI <35 ( $P = 0.03$ ); however, infection rates were similar. There was no significant difference in the rate of infection or nonunion for diabetic patients; however, a nonsignificant increased rate of nonunion was observed: 22.2% compared to 7.8% in nondiabetics ( $P = 0.08$ ). Fasciotomy closure/coverage prior to definitive fixation resulted in significantly fewer deep infections compared with internal fixation with open fasciotomy wounds: 11.8% compared to 50% ( $P = 0.02$ ). The presence of compartment syndrome, tobacco use, and timing of surgery had no impact on the rate of infection or nonunion.

**Conclusions:** (1) Nonunion and deep infections occur commonly after staged open reduction and internal fixation of high-energy tibial plateau fractures. (2) A BMI >35 was significantly associated with a higher rate of nonunion ( $P = 0.03$ ). (3) Open fractures and open fasciotomy wounds at time of definitive fixation were significantly associated with higher rates of infection ( $P = 0.02$ ).

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### Δ Risk Factors for Reoperation and Mortality Following the Operative Treatment of Tibial Plateau Fractures in Ontario 1996–2009

David Wasserstein, MD, MSc<sup>1</sup>; Hans J. Kreder, MD, MPH, FRCSC<sup>1,2</sup>; Michael Paterson, MSc<sup>2</sup>; Richard J. Jenkinson, MD, FRCSC<sup>1</sup>;

<sup>1</sup>Division of Orthopaedic Surgery, Sunnybrook Health Sciences Centre and University of Toronto, Toronto, Ontario, Canada;

<sup>2</sup>Institute for Clinical Evaluative Sciences, Toronto, Ontario, Canada

**Purpose:** We previously performed a population-based matched cohort study comparing rates of total knee replacement after operatively treated tibial plateau fractures (AO type 41A-C). The purpose of this study was to identify risks for reoperation (including revision and washout for deep infection) among patient, surgical, and provider factors within the surgical plateau fracture population cohort. Risk factors for early mortality were also examined.

**Methods:** Administrative datasets from the Province of Ontario were used to identify all patients who underwent operative fixation of the tibial plateau between 1996 and 2009. Patients younger than 16 years, non-Ontario residents, those with bilateral injuries, or who underwent knee replacement or tibial plateau fracture surgery in the 5 years prior to the index event were excluded. Outcomes included infection, revision, amputation, fusion, and hardware removal within 1 year of the index event, and 90-day mortality. Multivariate logistic regression analysis was fit to the data and included patient demographics, surgical (eg, fracture features), and provider (surgeon volume, academic hospital status, time of surgery—overnight and after 5 PM) factors as covariates. Odds ratios (OR) with 95% confidence intervals were calculated.

**Results:** The operative cohort included 8426 patients with a median age 48 years (interquartile range, 37–61) and 51.5% male. Markers of higher-energy injuries such as open fractures, procedures billed as bicondylar, or with an associated tibial shaft fracture increased the risk of reoperation and mortality (see table). Males were also at increased risk of infection (OR 1.7 [1.2–2.2],  $P = 0.0006$ ). Age each year above the mean increased mortality risk 10% (OR 1.1 [1.09–1.14],  $P < 0.0001$ ). Surgeon volume of procedure did not influence any outcome.

	Revision	Infection	Mortality
Open fracture	1.8 (1.3–2.5), $P = 0.0002$	3.2 (2.2–4.6), $P < 0.0001$	3.9 (1.8–8.6), $P = 0.0005$
Bicondylar	1.4 (1.2–1.7), $P < 0.0001$	2.7 (2.1–3.5), $P < 0.0001$	1.7 (1.0–2.8), $P = 0.04$
Associated shaft	0.5 (0.4–0.7), $P < 0.0001$	1.8 (1.4–2.4), $P < 0.0001$	2.3 (1.4–3.9), $P = 0.001$
Surgery after 5 PM	1.2 (1.05–1.5), $P = 0.01$	-	-
Overnight	2.1 (1.4–3.1), $P = 0.0002$	-	-
Academic (yes)	0.8 (0.7–0.9), $P = 0.01$	-	3.3 (1.9–5.7), $P < 0.0001$

**Conclusion:** Higher-energy fractures are at increased risk of infection and revision. After-hours surgery was an independent risk factor for revision fracture fixation and should be cautioned when not required (ie, outside of the emergency setting of an open fracture).

Δ OTA Grant

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## Radial Head Instability Following Malalignment of the Proximal Ulna: A Biomechanical Study

*Emilie Sandman, MD<sup>1,2</sup>; Fanny Canet, Ing Jr, MScA<sup>1</sup>; Yvan Petit, PhD<sup>1,3</sup>;*

*G. Yves Laflamme, MD, FRCSC<sup>1</sup>; George S. Athwal, MD, FRCSC<sup>4</sup>;*

*Dominique M. Rouleau, MD, MSc, FRCSC<sup>1</sup>;*

<sup>1</sup>Hôpital du Sacré-Cœur de Montréal, Montreal, Quebec, Canada;

<sup>2</sup>Université de Montréal, Montréal, Quebec, Canada;

<sup>3</sup>École de Technologie Supérieure, Montreal, Quebec, Canada;

<sup>4</sup>Hand and Upper Limb Center, St Joseph's Health Care, University of Western Ontario, Ontario, Canada

**Purpose:** Nonanatomic reconstruction of the elbow following a proximal ulna fracture/dislocation may lead to malunion, arthrosis, and instability. The proximal ulna has a sagittal plane bow, termed the proximal ulna dorsal angulation (PUDA), which measures between 0° and 14°. An understanding of the unique anatomy of the proximal ulna is important when treating complex injuries, such as Monteggia fracture/dislocations. Thus, the purpose of this study was to evaluate the magnitude of angular malalignment of the PUDA that would lead to radial head subluxation.

**Methods:** This biomechanical study was conducted on six fresh-frozen upper extremities. Testing was done on a validated motorized elbow movement simulator. An osteotomy, to simulate a proximal ulna fracture, was performed at the PUDA on each specimen. The osteotomy was stabilized with internal fixation at 5 angles (-10°, -5°, 0°, 5°, and 10°). Lateral elbow fluoroscopic images were taken in four elbow (maximal extension, 45°, 90°, maximal flexion) and three forearm (neutral, pronation, supination) positions during continuous elbow motion. The simulated fracture scenarios were done with an intact annular ligament and then, with annular ligament release. The displacement of the radial head was quantified with the radiocapitellar ratio (RCR), a previously validated measurement method. An RCR value of 100% represents a complete radial head dislocation. The relationships between radial head displacement and the degrees of malalignment of the proximal ulna, elbow, and forearm positions, and integrity of the annular ligament were assessed using an analysis of variance test.

**Results:** A significant triple interaction exists between elbow positions, angles of malalignment, and annular ligament integrity, when evaluating radial head instability with the RCR measurement ( $P < 0.001$ ). The greatest magnitudes of radial head subluxation were observed when the annular ligament was ruptured for all measurements ( $P < 0.001$ ), with a mean radial head displacement ranging from 4% posterior to 88% anterior. Significant differences were found between the different angles of internal fixation ( $P = 0.002$ ). Anterior subluxation of the radial head progressively increased as malalignment was fixed into extension. Indeed, the mean radial head displacement was 61% when the elbow was in maximal flexion, fixed at 10° of extension, and the annular ligament ruptured. Conversely, posterior subluxation increased as malalignment progressed into flexion. Additionally, significant differences were shown for different elbow positions ( $P < 0.001$ ). Anterior subluxation of the radial head increased as the elbow joint was moved from extension to flexion, while posterior subluxation

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of the radial head decreased as the elbow joint progressed towards flexion. However, there were no differences observed for forearm positions ( $P = 0.4$ ).

**Conclusion:** Our results demonstrate that malalignment of the proximal ulna leads to radial head instability. This is especially important, as fixation of the proximal ulna fractures are frequently done with straight plates that do not account for the normal anatomic bow, termed the PUDA. This malalignment may lead to abnormal tracking of the radial head, pain, restricted motion, and possibly secondary osteoarthritis. Malalignment of even  $5^\circ$  directly affects elbow biomechanics, especially with an associated annular ligament tear. Thus, this study demonstrates the importance of anatomic reconstruction of the proximal ulna, specifically recreation of each individual's unique PUDA.

## Ulnar Variance as a Predictor of Persistent Instability Following Galeazzi Fracture-Dislocations

Richelle C. Takemoto, MD<sup>1</sup>; Igor Immerman, MD<sup>1</sup>; Michelle Sugi, MD<sup>2</sup>;  
Nirmal C. Tejwani, MD<sup>1</sup>; Kenneth A. Egol, MD<sup>1</sup>;

<sup>1</sup>NYU Hospital for Joint Diseases, New York, New York, USA

<sup>2</sup>LAC-USC Medical Center, Los Angeles, California, USA

**Background/Purpose:** Currently, only the distance from the radiocarpal joint (RCJ) to the fracture has been identified as a predictor of distal radioulnar joint (DRUJ) instability in association with a radial shaft fracture. However, this measurement is not proportionalized to the differences in the length of the radial shaft. The purpose of this study was twofold: (1) evaluate the RCJ to fracture distance proportional to the length of the radial shaft and (2) to identify other injury and radiographic predictors of DRUJ instability associated with these fractures.

**Methods:** 50 patients who sustained 50 fractures of the radial shaft were identified and followed for a minimum of 6 months after surgery between 2003 and 2009. All radius fractures were treated with plate and screw fixation. Persistent DRUJ instability was defined as continued clinical instability following surgical fixation of the radial shaft. Medical records and radiographs were reviewed retrospectively. Demographic data, mechanism of injury, normalized preoperative injury ulnar variance, and the ratio of the distance from the RCJ to the fracture over the entire length of the radius were analyzed using the Fisher exact test and Student *t* test.

**Results:** 50 patients had persistent DRUJ instability following fixation of the radius fracture and were addressed operatively. As a proportion of radial length, the distance from the RCJ to the fracture line did not significantly differ between those with persistent DRUJ instability (0.37; range, 0.19-0.70; standard deviation [SD] = 0.12) and those without (0.34; range, 0.14-0.62; SD = 0.098) ( $P = 0.34$ ). The mean normalized injury-induced ulnar variance in the group with DRUJ instability was 5.5 mm (median, 4; range, 2-12 mm; SD = 3.2). The mean normalized preoperative injury ulnar variance in the group without DRUJ instability was 3.8 mm (median, 2.5; range, 0-11 mm; SD = 3.5). Only 4 of 20 patients (20%) with DRUJ instability had a normal ulnar variance (-2 mm to +2 mm) while 15 of 30 patients (50%) without DRUJ instability had a normal ulnar variance. This difference was statistically significant ( $P = 0.041$ ). There were no significant differences with respect to age, gender, presence of polytrauma, or the location of the fracture along the radius. Complications included one fracture nonunion and one peri-implant fracture at 9 months postoperatively.

**Conclusion:** In the setting of an isolated radial shaft fracture, injury-induced ulnar variance (as measured on initial injury radiographs) greater than +2 mm or less than -2 mm was associated with a greater likelihood of DRUJ instability following fracture fixation. Neither the absolute distance nor the ratio of distance from the RCJ to the fracture was predictive of persistent DRUJ instability.

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## Pathoanatomical Considerations and Implications of Heterotopic Ossification Following Surgical Treatment of Elbow Trauma

Bryce T. Gillespie, MD; George S.M. Dyer, MD;

Division of Hand and Upper Extremity Surgery, Department of Orthopaedic Surgery, Brigham and Women's Hospital, Boston, Massachusetts, USA

**Purpose:** This work was undertaken to develop a pathoanatomical classification system of heterotopic ossification (HO) following surgical treatment of elbow trauma based upon pre-excision imaging.

**Methods:** 36 patients who had undergone excision of HO following initial surgical treatment of periarticular skeletal elbow trauma were identified. Pre-excision imaging studies (including elbow radiographs alone or combined with CT scans) were reviewed independently to identify common patterns of HO. Injury pattern, elbow range of motion (ROM) data, and surgical characteristics were analyzed. One-way analysis of variance with Tukey's post-hoc type 1 error adjustment was used to determine pairwise differences for the ROM data. Fisher's exact test was used to compare the relationship between surgical characteristics and AO fracture classification with the five HO patterns.

**Results:** Five patterns of HO were identified, including anterolateral elbow, anterior distal humerus, coronoid and olecranon fossae, proximal radioulnar joint (PRUJ), and posteromedial elbow / other. Significant differences were found between the five patterns when comparing pre-excision flexion arc ( $P = 0.0355$ ), flexion arc gain ( $P = 0.0386$ ), pre-excision rotation arc ( $P = 0.0014$ ), and rotation arc gain ( $P = 0.0004$ ). The PRUJ pattern had a significantly greater pre-excision flexion arc than the anterolateral pattern (95% confidence interval [CI]: 2.5-96.1). Comparing pre-excision rotation arc, the anterior pattern was significantly greater than the PRUJ pattern (95% CI: 25.6-228.4) and the fossae pattern was significantly greater than the anterolateral and PRUJ patterns (95% CI: 1.7-143.8 and 35.2-218.0, respectively). For rotation arc gained, the PRUJ pattern gained significantly more than the anterior and fossae patterns (95% CI: 19.8-192.2 and 42.8-198.2, respectively). Overall, the mean pre-excision flexion arc was 58° and improved to 100° at final follow-up (mean of 41 weeks) after excision of HO. The mean forearm rotation arc improved from 97° to 146°. The postexcision flexion and rotation arcs were not significant differently between the five patterns. There is a significant association between the five patterns and AO fracture classification. The anterior and fossae patterns were more often AO 13 than AO 21. Subjects with PRUJ and posteromedial/other patterns were exclusively AO 21, while subjects with the anterolateral pattern were divided between AO 13 (5 subjects) and AO 21 (9 subjects).

**Conclusions:** Several distinct patterns of HO about the elbow are identifiable and may have implications on elbow ROM and expected outcomes. Anterolateral HO appears to have restricted ulnohumeral and forearm motion. Anterior and fossae patterns were related to restricted ulnohumeral motion, while PRUJ HO was related to restricted forearm rotation. The postexcision flexion and rotation arcs are similar for all five patterns and comparable to previously published data regarding surgical treatment of elbow HO. Injury pattern may also be related to the subsequent morphology of HO. Anterior and fossae patterns develop more frequently following distal humerus fractures (AO 13) than proximal forearm injuries

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(AO 21). PRUJ and posteromedial/other patterns develop exclusively following proximal forearm injuries. The anterolateral pattern developed following either an AO 13 or AO 21 injury.

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**Nonoperative Management of Displaced Olecranon Fractures**

*Andrew D. Duckworth, MBChC,BSc (Hons); Kate E. Bugler; Nicholas D. Clement, MBBS; Charles M. Court-Brown, MD; Margaret M. McQueen, MD; Edinburgh Orthopaedic Trauma Unit, Royal Infirmary of Edinburgh, Edinburgh, Scotland, United Kingdom*

**Purpose:** Recent literature has documented the increasing mean age of olecranon fractures, with many now considering it a fragility fracture. Given this, it is now recognized that work is required to determine if the surgical treatment for displaced olecranon fractures in lower-demand patients, and/or patients with multiple comorbidities, provides a significant benefit over nonoperative management. The aim of this study was to document both the short- and long-term outcome of isolated displaced olecranon fractures treated with primary nonoperative intervention.

**Methods:** We identified from our prospective trauma database all patients who were managed nonoperatively for a displaced olecranon fracture over a 13-year period. Inclusion criteria included all fractures of the olecranon (OTA 21-B1.1) with >2 mm displacement of the articular surface. Comminuted fractures were included. Patients were excluded if there was inadequate data or if they had sustained an open fracture or a fracture dislocation. Demographic data, fracture classification (OTA and Mayo), management, complications, and subsequent surgeries were recorded. The primary short-term outcome measure was the Broberg and Morrey elbow score. The primary long-term outcome measure was the Disabilities of the Arm, Shoulder and Hand (DASH) and Oxford Elbow Score.

**Results:** There were 43 patients in the study cohort with a mean age of 76 years (range, 40-98) and 65% (n = 28) were female. A low-energy fall from standing height accounted for 84% of all injuries. One or more significant comorbidities was documented in 88% (n = 38) of patients. Mayo type 2A fractures were the most common fracture type (n = 33, 76.7%), with 10 patients noted to have fracture comminution (n = 10, 23.3%). A collar and cuff followed by active mobilization was used in 15 patients (35%), with an above-elbow plaster cast with the elbow in 60° to 90° of flexion used in 28 cases (65%). At a mean short-term follow-up of 4 months (range, 1.5-10), the mean flexion arc was 109° (range, 50°-135°) and the mean Broberg and Morrey score was 83 (range, 48-100), with 73% achieving an excellent or good short-term outcome. No patients underwent further surgery for a symptomatic nonunion. Long-term follow-up was available in 53% of patients (n = 21), with the remainder deceased. At a mean of 6 years (range, 2-15) after injury, the mean DASH score was 2.9 (range, 0-33.9), the mean Oxford Elbow Score was 47 (range, 42-48), and overall patient satisfaction was 91% (n = 21).

**Conclusions:** To our knowledge, this is the largest series in the literature documenting both the short- and long-term outcome following nonoperative management for a displaced fracture of the olecranon. From our data, we would suggest that nonoperative management of displaced olecranon fractures in lower-demand elderly patients with multiple comorbidities produces a good or excellent long-term patient-reported outcome. Further work is required to directly compare operative and nonoperative management in this patient group.

**Minimally Displaced Clavicle Fracture on Initial Trauma Survey: A Benign Injury?**

*John Riehl, MD; Bill Athans, MD; Mark Munro, MD; Joshua Langford, MD; Stanley Kupiszewski, MD; George J. Haidukewych, MD; Kenneth J. Koval, MD; Orlando Regional Medical Center, Orlando, Florida, USA*

**Purpose:** Minimally displaced clavicle fractures are often considered to be a benign injury. However, it has been our experience that minimally displaced clavicle fractures on initial chest radiograph in patients sustaining high-energy trauma may displace during the early follow-up period and therefore warrant close radiographic follow-up. This study was performed to evaluate subsequent fracture displacement in patients sustaining high-energy trauma when a supine chest radiograph on initial trauma survey revealed a well-aligned clavicle fracture.

**Methods:** This was a retrospective review of patients treated at a Level I trauma center from 2005–2010. Inclusion criteria consisted of: (1) trauma alert patient, (2) patient age  $\geq 18$  years, (3) a midshaft clavicle fracture (AO/OTA type 15-B) present on initial survey supine chest radiograph, (4) initial fracture displacement  $< 100\%$  of the clavicle shaft width, and (5) follow-up radiographs between 2 days and 6 weeks of injury clearly showing the clavicle. Initial analyses were performed to determine the rate of fracture displacement  $> 100\%$  of the shaft width on follow-up radiographs. Secondary analyses evaluated those fractures that had initial displacement  $\leq 3$  mm who later displaced  $> 100\%$ . This definition of displacement was based on previous work that showed displacement of  $100\%$  to be predictive of nonunion.

**Results:** 95 clavicle fractures met the inclusion criteria. On follow-up, 57 of 95 fractures (60%) had displacement  $> 100\%$  of the shaft width. Of these 57 patients, 12 (21%) had subsequent surgical stabilization. 31 of 95 patients (33%) had initial fracture displacement  $\leq 3$  mm (group A) while the remaining 64 had displacement  $> 3$  mm but  $< 100\%$  of the clavicle shaft width (group B). In group A, 10 of 31 fractures (32%) had displacement  $> 100\%$  of the shaft width on follow-up radiographs. This displacement was evident at 7 days in 7 of 10 patients, and in all 10 patients by 3 weeks. The subsequent displacement of these fractures from initial to follow-up radiographs averaged 15 mm (range, 8–25 mm). Three of ten patients in group A (30%) had subsequent surgical stabilization. In group B, 47 of 64 fractures (73%) had fracture displacement  $> 100\%$  of the shaft width on follow-up radiographs. This displacement was evident at 7 days in 31 of 47 patients (66%), and in 44 of 47 patients (94%) by 3 weeks. 9 of 47 patients in group B (19%) underwent subsequent surgical stabilization.

**Conclusion:** Clavicle fractures in patients who sustain a high-energy injury have a high propensity to displace on follow-up radiographs, even when initially minimally displaced. 60% of minimally displaced fractures on initial supine chest radiograph had  $> 100\%$  displacement on early follow-up. One-third of fractures with initial displacement  $\leq 3$  mm had subsequent displacement  $> 100\%$ . This displacement may change subsequent fracture management in order to provide optimal patient outcomes. We recommend close follow-up of all clavicle fractures to evaluate for subsequent fracture displacement.

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**Progressive Displacement After Clavicle Fracture: An Observational Study***Erich M. Gauger, MD<sup>1</sup>; Aaron R. Jacobson, DC<sup>1</sup>; Ryan E. Will, MD<sup>2</sup>; Peter A. Cole, MD<sup>1</sup>;**<sup>1</sup>University of Minnesota, Minneapolis, Minnesota, USA;**<sup>2</sup>Multicare Health System, Tacoma, Washington, USA*

**Purpose:** Certain amounts of clavicle fracture displacement have been associated with poor functional outcome, making the ability to measure this displacement an important diagnostic goal. There is variability, however, in radiographic technique on shoulder images. Additionally, it has been shown that a subset of clavicle fractures progressively displace in the peri-injury time period. The purpose of this study is to (1) describe the incidence of progressive displacement greater than 1 cm in the peri-injury time frame, (2) compare different methods of measuring clavicle displacement using interobserver reliability, and (3) determine whether supine versus upright position during radiography changes measured displacement.

**Methods:** This was a prospective observational study in which 60 consecutive patients diagnosed with a displaced midshaft clavicle fracture had a specific radiographic protocol. All patients presenting with a midshaft clavicle fracture within 7 days of injury met inclusion. In addition, inclusion required at least one follow-up with protocol-defined radiographs. The protocol included 3 views: (1) standing 15° cephalic tilted AP, (2) supine 15° cephalic tilted AP clavicle, and (3) supine 15° cephalic tilted AP panoramic shoulder girdle view. Vertical displacement and clavicle shortening was independently measured by 2 trained examiners at all time points to detect changes resulting from patient positioning and time from injury. To analyze whether time from injury affected the difference between upright and supine displacement measurements, radiographs were categorized into 3 groups: (1) images taken on days 0-6 postinjury (n = 66), (2) days 7-21 postinjury (n = 46), and (3) days 22 or greater postinjury (n = 29).

**Results:** 60 patients had initial films at a mean of 1 day after injury with the second set of films done at a mean of 12 days after the initial radiographs. 30 patients had a third set of radiographs done at a mean of 41 days after the initial radiographs. Between the initial and the final follow-up radiograph, 6 patients (10%) had progressive medialization greater than 1 cm and 13 patients had progressive translation (22%) greater than 1 cm. The interobserver reliability as determined by the concordance correlation coefficient was nearly perfect for the measurement of medialization (0.929), translation (0.982), and length of injured clavicle (0.996). Analysis showed that upright radiographs had 11%, 27%, and then 10% greater medialization compared to supine in the respective time categories (0-6 days, 7-21 days, 22+ days). Upright images also showed 16%, 19%, and then 9% greater translation than supine in the respective time categories. Statistical analysis comparing medialization and translation from upright to supine at all time points revealed significant differences ( $P < 0.05$ ). These data would suggest that the difference between upright and supine displacement measurements diminished over time as would be expected due to consolidation of the fracture.

**Conclusion:** Our data show that close follow-up of nonoperatively treated clavicle fractures is warranted due to the risk of progressive displacement. The data also show that upright gravity views highlight displacement both for medialization and translation of the fracture.

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We therefore recommend consideration of a change in radiographic protocol that mandates upright films when possible, since measurements of displacement in this position may affect surgical decision making.

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### **Prognostic Factors for Reoperation Following Plate Fixation of Fractures of the Midshaft Clavicle**

*Laura A. Schemitsch; Emil H. Schemitsch, MD; Paul R. Kuzyk, MD; Michael D. McKee, MD; Milena R. Vicente, RN, CCRP; St. Michael's Hospital, Toronto, Ontario, Canada*

**Purpose:** Plate fixation of midshaft fractures of the clavicle has become an accepted treatment technique for completely displaced injuries. However, little information is available regarding reoperation, a frequent concern. We conducted a retrospective review to determine which prognostic factors were associated with reoperation following plate fixation of completely displaced midshaft fractures.

**Methods:** We identified 235 consecutive patients who underwent plate fixation for a midshaft clavicle fracture at a single university-affiliated Level I trauma center between July 1, 2000 and July 1, 2009. We examined for 21 possible prognostic variables using multivariate logistic regression analysis and documented reoperation rates.

**Results:** 235 were identified. 82 patients had less than 2-year follow-up and were excluded from the study: none of these patients had had any further surgery at the time of last follow-up. 153 patients were contacted and assessed (65% of the total cohort). 58 of these patients had had reoperations (38%), with 8 of these individuals requiring multiple procedures (5%). The majority of individuals had reoperation for plate removal (50 of 153, 33%), while the others were for nonunion, hardware failure, refracture, or infection (8 of 153, 5%). Plate removal was associated with the use of straight, noncontoured plates, and height <175 cm ( $P < 0.01$ ). Risk factors for multiple reoperations (ie, for infection, nonunion, fixation failure, etc) included substance abuse (illicit drugs or alcohol), diabetes, and age >55 years ( $P < 0.01$ ). This information can be used prognostically: for example, use of a contoured plate in a person >175 cm tall results in a plate removal rate of only 9%. Conversely, substance abuse increases the risk of requiring multiple reoperations from 3% to 25%.

**Conclusions:** We have presented the largest series to date that defines the rate of, and risk factors associated with, reoperation following plate fixation of displaced midshaft fractures of the clavicle. Our assessment of 153 patients provides some useful clinical information for treatment and prognosis. Plate fixation of the clavicle is a safe, reliable operation with a low major complication rate (5%). The rate of plate removal is significant (33%), and associated with the use of straight plates; precontoured plates decrease this rate. Shorter (smaller) patients had an increased rate of plate removal and can be counseled accordingly. Patients with substance abuse issues, diabetes, or age >55 years had a significantly higher need for multiple reoperations due to serious complications such as fixation failure or infection. Given the relatively narrow risk-benefit profile of clavicle fracture fixation, extreme caution should be used in recommending primary operative repair in these individuals.

### Four-Part Fractures of the Proximal Humerus: Outcomes of Surgical and Nonsurgical Management

Brian D. Solberg, MD; David A. Friedberg, MD; Dennis P. Franco, MD;  
California Hospital Medical Center, Los Angeles, California, USA

**Purpose:** This study was undertaken to compare the mid/long-term outcomes of a cohort of patients followed prospectively after sustaining a four-part proximal humerus fracture treated conservatively, with locked plating or hemiarthroplasty.

**Methods:** This prospective, nonrandomized IRB-approved was conducted at multiple Level I and II trauma centers. 162 patients were followed prospectively after sustaining a Neer four-part proximal humerus fracture. Three treatment groups were identified: nonsurgical management, hemiarthroplasty, and repair using a locked plate. Patients were followed prospectively and outcomes were compared using the Constant scoring system. Radiographic measures included the development of osteonecrosis of the humeral head, progressive subsidence, and loss of fixation. Complications in each group and the rate of reoperation or conversion to hemiarthroplasty for each group were also assessed.

**Results:** 34 patients had nonsurgical management of their fractures, 79 had surgical repair using a locked plating construct, and 49 patients underwent hemiarthroplasty for Neer four-part fractures. There were no differences between groups with regard to age, sex, average follow-up, or AO and OTA fracture types ( $P > 0.35$ ). At an average follow-up of 58 months, Constant scores (CS) were similar ( $P = 0.24$ ) for the hemiarthroplasty ( $59 \pm 6$ ) and nonsurgical management ( $61 \pm 7$ ), while patients who underwent repair with a locked plate ( $67 \pm 6$ ) had a significantly better clinical outcome ( $P = 0.02$ ). Patients with initial varus displacement of the articular fragment had a worse outcome and higher conversion rate to hemiarthroplasty (CS  $55 \pm 7$ , 53% conversion) than patients with initial valgus displacement (CS  $71 \pm 8$ , 14% conversion) ( $P = 0.01$  and  $0.03$ , respectively). The overall rate of osteonecrosis was 34%, while the odds ratio (OR) was increased significantly with dislocation (OR = 2.4) and metaphyseal hinge length of less than 4 mm (OR = 8.4) ( $P = 0.04$  and  $< 0.01$ , respectively). The rate of reoperation was higher in the locked plating group (22%) than in the hemiarthroplasty group (14%,  $P = 0.03$ ) while almost half (41%) of patients treated conservatively were eventually converted to hemiarthroplasty for pain relief.

**Conclusions:** Locked plating of Neer four-part proximal humeral fractures led to significantly better outcomes than hemiarthroplasty or conservative management despite having a higher complication rate. Fracture patterns with initial varus displacement of the articular fragment had worse overall outcomes and higher rate of conversion to hemiarthroplasty than valgus-impacted patterns. Osteonecrosis developed in roughly one in three patients but was not associated with worse outcomes than patients treated with hemiarthroplasty or conservative management.

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## Fractures of the Greater Tuberosity of the Humerus: A Study of Associated Rotator Cuff Injury and Atrophy

*Luojun Wang<sup>1</sup>; Jennifer Mutch<sup>2</sup>; George-Yves Laflamme, MD<sup>2</sup>; Nicola Hagemeister<sup>3</sup>; Dominique M. Rouleau, MD<sup>2</sup>;*

*<sup>1</sup>Université de Montréal, Montreal, Quebec, Canada;*

*<sup>2</sup>Hôpital du Sacré-Coeur de Montréal, Université de Montréal, Montreal, Quebec, Canada;*

*<sup>3</sup>Centre Hospitalier de l'Université de Montréal, École de Technologie Supérieure, Montreal, Quebec, Canada*

**Purpose:** Fractures of the greater tuberosity represent a particular challenge as tendinomuscular injuries of the rotator cuff may occur in conjunction. MRI performed after proximal humerus fractures in general has shown an incidence of 40% full-thickness rotator cuff tears. In addition, the degree of fatty muscle atrophy has been shown to correlate with functional outcome in rotator cuff tears and shoulder arthroplasty but no study has been done following isolated greater tuberosity fracture. The objective of this study is to evaluate the incidence of full-thickness rotator cuff tear and bicipital pathologies in patients with previous greater tuberosity fracture.

**Methods:** All cases of isolated greater tuberosity fractures seen at our institution from July 2007 until December 2010 were reviewed. 50 patients with adequate initial radiographs were invited to return for an ultrasound of their affected shoulder; the contralateral shoulder was used for comparison. The examinations were performed by a single experienced musculoskeletal radiologist. Tendinosis, tears, and position of the biceps tendon were noted and any partial or complete rotator cuff tears were identified and measured. A dynamic evaluation assessed subacromial impingement. Atrophy of the supraspinatus and infraspinatus muscles was measured using the occupation ratio validated by Khoury et al. Fatty infiltration was evaluated by comparing rotator cuff muscle echogenicity to that of the deltoid and trapezius muscles. Quick Disabilities of the Arm, Shoulder and Hand (Q-DASH), Short Form-12 (SF-12), Western Ontario Rotator Cuff Index (WORC), and pain score were used to assess clinical outcome.

**Results:** The 50 recruited patients had an average age of 58 (standard deviation [SD]: 15; range, 32-92) and 45% were male. 66% of the ultrasounds demonstrated at least one partial tear. Six patients showed full-thickness tear; all of them were male. Biceps evaluation showed 11 subluxations (22%) and 28 tendinitis (56%). 53% of all patients had evidence of subacromial impingement. The average surface ratios of the supraspinatus and infraspinatus muscles of the affected and unaffected side were not significantly different (0.79 and 0.76). However, fatty infiltration was present in 11 supraspinatus (22%) and 26 infraspinatus (52%) muscles of the affected side. Patients with full-thickness tears had worse upper limb function as shown by the Q-DASH. (average 35 vs 16,  $P = 0.05$ ). They were also reporting more pain (average 3.5 of 10 vs 1.7 of 10,  $P = 0.05$ ). The biceps subluxation was associated with higher WORC score (average 89 vs 73,  $P = 0.05$ ).

**Conclusion:** This study describes the tendinous pathology associated with isolated greater tuberosity fractures of the proximal humerus. Following these fractures, a significant portion of patients were shown to have rotator cuff pathology regardless of age. More than half of the patients demonstrated evidence of subacromial impingement. Patients with greater tuberosity fractures may therefore benefit from additional imaging to evaluate their rotator cuff.

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## The Impact of Preoperative Coronal Plane Deformity on Proximal Humerus Fixation With Endosteal Augmentation

Milton T.M. Little, MD; Marschall B. Berkes, MD; Patrick C. Schottel, MD;  
Lionel E. Lazarao, MD; Lauren E. Lamont, MD; Nadine C. Pardee, BS; David L. Helfet, MD;  
Dean G. Lorich, MD;  
Hospital for Special Surgery/New York Presbyterian-Cornell, New York, New York, USA

**Purpose/Hypothesis:** The development of angular stable implants has increased the frequency of proximal humerus fracture fixation, but risk factors for poor outcomes remain prevalent. Literature suggests that varus deformity at presentation is associated with poorer clinical and radiographic outcomes. The purpose of this study was to compare radiographic, clinical, and functional outcomes among fractures treated with endosteal augmentation in patients presenting with varus or valgus deformity of the proximal humerus. We hypothesize that endosteal augmentation may help to overcome the fixation difficulties associated with varus presentation and yield equivalent outcomes between the two groups.

**Methods:** All proximal humerus fractures presenting to a single surgeon at a Level I trauma center from 2005 to 2011 were compiled in a prospectively collected database. A retrospective review of this database was performed. All patients were treated through the anterolateral approach with endosteal strut augmentation of laterally placed angular stable plating. Three separate reviewers independently examined preoperative, postoperative, and final radiographs; injury radiographs were evaluated for medial calcar comminution (>3 fracture fragments). Postoperative radiographs were reviewed to assess the quality of reduction (<5 mm of calcar reduction, neck-shaft angle between 120° and 145°) and compared to final follow-up radiographs to assess for loss of reduction as described by Gardner et al. Functional outcome scores were compiled by an independent reviewer for University of California at Los Angeles (UCLA) shoulder rating score, the Disabilities of the Arm, Shoulder and Hand (DASH) score, and Short Form 36 health survey (SF-36) at least 1 year postoperatively.

**Results:** 91 patients fulfilled our inclusion criteria with a mean of 12 months of radiographic follow-up. The mean age was 63 years old (range, 26-90) and 66% were female. 49 fractures presented with varus displacement (mean neck-shaft angle 112.42°, standard deviation [SD] 14.61) and 42 with valgus (mean neck-shaft angle 168.7°, SD 15.14) displacement. There was no significant difference in the rate of fracture reduction (varus 86% vs valgus 71%,  $P = 0.10$ ), loss of reduction (varus 10% vs valgus 24%,  $P = 0.25$ ), calcar comminution, DASH, or UCLA scores between the two cohorts. Despite those findings, the varus group had on average significantly worse forward flexion (150° vs 161°,  $P = 0.023$ ) and lower SF-36 physical component summary scores (55.3 vs 66.7,  $P = 0.03$ ).

**Conclusion:** Despite equivalent rates of fracture reduction and maintenance of reduction, fractures presenting with varus coronal deformity had worse functional outcome as measured by the SF-36 physical component summary and forward flexion. Further investigation is warranted to evaluate other factors associated with varus presentation and their propensity for poor outcomes despite adequate reduction.

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## **Δ Operative Versus Nonoperative Treatment of Acute Dislocations of the Acromioclavicular Joint: Results of a Multicenter Randomized, Prospective Clinical Trial**

*Michael D. McKee, MD; Stéphane Pelet, MD, PhD, FRCSC; Milena R. Vicente, RN, CCRP; The Canadian Orthopaedic Trauma Society (COTS) Group; St. Michael's Hospital, Toronto, Ontario, Canada*

**Purpose:** The optimal treatment for acute dislocation of the acromioclavicular (AC) joint remains unclear. Both surgical repair and nonoperative treatment have been advocated, but prior randomized trials did not reveal any significant differences between groups. However, these studies used inferior surgical techniques and surgeon-based or radiographic outcome measures. We sought to perform a randomized clinical trial of operative versus nonoperative treatment of acute AC joint dislocations using modern surgical fixation and patient-based outcome measures.

**Methods:** We performed a prospective, multicenter, randomized clinical trial comparing operative repair with hook plate fixation versus nonoperative treatment for acute (<3 weeks old) complete (grades III, IV, V) dislocations of the AC joint. The primary outcome measure was the Disabilities of the Arm, Shoulder and Hand (DASH) score at 1 year postinjury. Assessment also included a complete clinical assessment, the Constant score, the Short Form-36 score, and a radiographic evaluation at 6 weeks, and at 3, 6, 12, and 24 months.

**Results:** 83 patients were randomized (operative repair 40, nonoperative treatment 43). There were no demographic differences between the two groups (operative: male/female 36/4, nonoperative 42/1,  $P = 0.279$ ; mean age operative group 38.7 years, nonoperative group 37.3 years,  $P = 0.778$ ). The mechanisms of injury were similar between the two groups. DASH scores (a disability score—lower score is better) were significantly better in the nonoperative group at 6 weeks (operative 46, nonoperative 31,  $P = 0.007$ ), and 3 months (operative 29, nonoperative 16,  $P = 0.01$ ). There were no significant differences between the groups at 6 months (operative 14, nonoperative 12,  $P = 0.422$ ), 1 year (operative 10, nonoperative 9,  $P = 0.997$ ), or 2 years (operative 4, nonoperative 6,  $P = 0.492$ ) postinjury. Similar values were seen for Constant scores at 6 weeks (operative 51, nonoperative 75,  $p < 0.0001$ ), 3 months (operative 69, nonoperative 85,  $P = 0.001$ ), 6 months (operative 80, nonoperative 92,  $P = 0.001$ ), 1 year (operative 91, nonoperative 91,  $P = 0.830$ ) and 2 years (operative 93, nonoperative 89,  $P = 0.352$ ). There were four major complications in the hook plate group (acromial erosion, 2; plate failure, 2). Radiographic outcomes and joint reduction were significantly better in the operative group.

**Discussion:** Hook plate fixation with presently available implants is not superior to nonoperative treatment for the treatment of acute, complete dislocations of the AC joint. The nonoperative group had better early scores, although both groups improved from a significant level of initial disability to a good or excellent result (mean DASH score <5, mean Constant score >90) at 2 years. Although joint reduction is reliably restored with hook plate fixation, there is no clear evidence that this operative treatment improves short-term outcome for complete AC joint dislocations. Further research and long-term follow-up is required.

Δ OTA Grant

See pages 97 - 144 for financial disclosure information.

**Acute Compartment Syndrome of the Forearm**

*Andrew D. Duckworth, MBChB, BSc (Hons); Sarah E. Mitchell, MRCSEd;  
Samuel G. Molyneux, MRCSEd; Timothy O. White, MD, FRCS;  
Charles M. Court-Brown, MD; Margaret M. McQueen, MD;  
Edinburgh Orthopaedic Trauma Unit, Royal Infirmary of Edinburgh,  
Edinburgh, Scotland, United Kingdom*

**Purpose:** The aim of this study was to document our experience of acute forearm compartment syndrome, and to determine the risk factors for requiring split-skin grafting (SSG) and developing complications postfasciotomy.

**Methods:** We identified from our trauma database all patients who underwent fasciotomy for an acute forearm compartment syndrome over a 22-year period. Diagnosis was made using clinical signs, with compartment pressure monitoring, or a combination of the two. Demographic data, etiology, management, wound closure, complications, and subsequent surgeries were recorded. Outcome measures were the use of SSG and the development of complications following forearm fasciotomy.

**Results:** There were 90 patients in the study cohort with a mean age of 33 years (range, 13-81) and a significant male gender predominance ( $n = 82$ ,  $P < 0.001$ ). A fracture of one or both of the forearm bones was seen in 62 patients (69%), with soft-tissue injuries causative in 28 (31%). The median time to fasciotomy was 12 hours (range, 2-72). A volar compartment decompression was performed most frequently ( $n = 89$ , 99%). Delayed wound closure was achieved in 38 patients (42%), with 52 (58%) requiring SSG. Risk factors for requiring SSG were younger age and a crush injury (both  $P < 0.05$ ). Complications occurred in 29 patients (32%) at mean follow-up of 11 months (range, 3-60). Risk factors for developing complications were a delay in fasciotomy of  $>6$  hours ( $P = 0.018$ ), with preoperative motor symptoms approaching significance ( $P = 0.068$ ).

**Conclusions:** To our knowledge, this is the largest series in the literature of acute forearm compartment syndrome with the etiology, diagnosis, management, and complications reported in a consecutive group of patients. We have shown forearm compartment syndrome requiring fasciotomy predominantly affects males and can occur following either a fracture or soft-tissue injury. Age is an important predictor of undergoing SSG for wound closure. Complications occur in a third of patients and are associated with an increasing delay in the time to fasciotomy.

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**Cast Immobilization With and Without Immobilization of the Thumb for Nondisplaced Scaphoid Waist Fractures: A Multicenter Randomized Controlled Trial**

*Geert A. Buijze, MD; J. Carel Goslings, MD; Steven J. Rhemrev, MD; Alexander A. Weening, MD; Bart Van Dijkman, MD; Job N. Doornberg, MD; David C. Ring, MD, PhD; CAST (Collaborative Ankle Support Trial) Collaboration; Massachusetts General Hospital, Boston, Massachusetts, USA*

**Purpose:** This trial was conducted to test the null hypothesis that there is no difference in union or arm-specific disability between nondisplaced scaphoid waist fractures treated in a below-elbow cast including or excluding the thumb.

**Methods:** 55 patients with a nondisplaced fracture of the scaphoid waist were enrolled in a prospective multicenter randomized controlled trial comparing treatment in a below-elbow cast including the thumb with a below-elbow cast excluding the thumb. Due to a misunderstanding at some centers, 7 distal scaphoid fractures were enrolled during the early part of the trial for a total of 7 distal and 55 waist fractures. We adhered to strict intention-to-treat principles. The primary study question addressed the extent of union on CT performed after 10 weeks of cast treatment and expressed as a percentage of the fracture line that had bridging bone by musculoskeletal radiologists blinded to treatment. Secondary study questions addressed wrist motion, grip strength, Mayo wrist scores, DASH (Disabilities of the Arm, Shoulder and Hand) scores, pain, and union at 6 months after treatment.

**Results:** There was a significant, but clinically irrelevant, difference in the extent of union on CT at 10 weeks (85% vs 70%), favoring treatment with a cast excluding the thumb. One waist fracture treated with the thumb immobilized elected operative treatment 1 week after enrollment used crutches and developed nonunion (98% union overall; 100% union with nonoperative treatment). There were no significant differences between the groups for wrist motion, grip strength, Mayo wrist scores, DASH scores, pain scores, or union.

**Conclusion:** Fractures of the scaphoid waist can be adequately treated in a below-elbow cast excluding the thumb.

## The Correlation of Age and Short-Term Outcomes in Patients Who Have Undergone Operative Fixation of Distal Radius Fractures

*John W. Karl, MD, MPH; Patrick R. Olson, MD, MS, MPH; Melvin P. Rosenwasser, MD; Columbia University Medical Center, Department of Orthopedics, New York, New York, USA*

**Purpose:** There is considerable controversy regarding the optimal treatment of distal radius fractures, particularly in the elderly, despite national trends suggesting significant increases in operative fixation. Our aim was to report on the outcomes, as correlated by age, of these patients in our prospective cohort study of operatively treated distal radius fractures.

**Methods:** The Distal Radius Study Group (DRSG) is a prospectively studied group of patients with distal radius fractures of all types and all ages who presented to our institution. Using these data, 223 unstable distal radius fracture patients treated with surgical fixation with a mean age of 55.6 years (range, 18-85 years) were followed prospectively for a mean of 6 months. Functional assessment was performed using the Disabilities of the Arm, Shoulder and Hand (DASH), wrist range of motion (pronation, supination, wrist flexion, extension), and pinch and grip strength. Pain was assessed by resting visual analog scale (VAS), active VAS, and resting and active verbalized pain on a scale from 0 to 10. Linear regression models were used to identify correlations of age and outcomes.

**Results:** In this prospective cohort study of operatively treated distal radius fractures, as patient age increased, physical function decreased, as measured by DASH scores (coef. = 0.231,  $P = 0.018$ ,  $R^2 = 0.025$ ). Similarly, older patients experienced more pain compared with their younger peers, as measured by verbalized resting pain (coef. = 0.040,  $P = 0.014$ ,  $R^2 = 0.083$ ). These correlations remained when controlling for length of follow-up. There were no differences, however, between age groups when assessing resting VAS, active VAS, or verbalized pain with activity, pronation, supination, wrist flexion, extension, and grip and pinch strength.

**Conclusion:** In this prospective cohort study of patients who have undergone operative fixation of distal radius fractures, more mature patients demonstrate worse functional outcomes (as measured by DASH score) and verbalized more resting pain compared with their younger peers. Understanding these outcomes as they pertain to age is critical, especially considering recent research demonstrating no marked benefit to operative fixation of distal radius fractures in the elderly compared with nonoperative management.

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## Alignment in Nonoperatively Treated Distal Radius Fractures: Are Our Current Predictors Predictive?

Joey Lamartina, MD; Charlton Stucken, MD; Andrew Jawa, MD; Paul Tornetta III, MD;  
Boston University Medical Center, Boston, Massachusetts, USA

**Background/Purpose:** Multiple methods have been described to predict loss of reduction in distal radius fractures treated nonoperatively. We sought to independently validate the McQueen equation and LaFontaine's criteria in a large series of distal radius fractures treated nonoperatively. Additionally, we wished to evaluate postreduction volar cortical alignment (volar hook) and a specific definition for dorsal comminution on the final reduction of these patients. We hypothesized that restoring the volar cortical integrity would aid in maintenance of the volar tilt by a standard three-point molded cast.

**Methods:** We prospectively screened 546 consecutive distal radius fractures using the McQueen equation and LaFontaine's criteria for instability. We excluded patients with  $<10^\circ$  of dorsal tilt upon presentation, leaving 275 fractures of which 168 were treated nonoperatively and form the basis of this study. Patients were managed with short arm casts and seen every other week in the clinic by an attending orthopaedic trauma surgeon. Patients were recasted if there was thought to be a shift in the fracture position or if the cast became loose. We measured the following parameters on the initial reduction and final radiographs: dorsal tilt, radial height, radial inclination, ulnar variance, and the presence of carpal malalignment. We defined dorsal comminution as having a loss of the dorsal cortex of  $\geq 5\text{mm}$  on the postreduction lateral radiograph. We defined "volar hook" as having collinear alignment of the cortical edges of the fracture at the volar surface. We performed univariate analysis to determine how predictive the McQueen percentage and the number of Lafontaine's criteria present were on each radiographic parameter. Additional univariate analyses were done on the radiographic components of each score, volar hook, sex, and age. Based on the univariate analysis of the various predictors, a multivariate analysis was done including age, dorsal comminution (DC), volar hook (VH), and intra-articular fracture (IAF) against all radiographic outcome parameters and any change in those parameters during healing.

**Results:** In the univariate analysis, the McQueen percentage and the total number of LaFontaine's criteria present predicted the change in radial height and inclination. The change in dorsal tilt was predicted by VH and DC. The change in ulnar variance was predicted by DC and IAF. The change in radial height was predicted by IAF and age and the change in radial inclination was predicted only by age. Final dorsal tilt was predicted by VH, DC, and sex. Carpal malalignment at healing was predicted by VH and age. The table details the results of the multivariate analysis.

**Table** Factors that were statistically significant in the multivariate analysis for each radiographic outcome

	Dorsal Tilt	Ulnar Variance	Radial Height	Radial Inclination
Final position	VH, DC	DC	Age	Age
Change during treatment	VH, DC	Age	Age, IAF	Age, DC

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**Discussion:** We attempted to validate the McQueen percentage and Lafontaine's criteria on the final radiographic position and the change in position over time in 168 consecutive patients with displaced distal radius fractures treated nonoperatively. Additionally, using a multivariate technique, we found that VH and DC were strong predictors of final dorsal tilt and the change in angulation during healing. Age was the most important factor in predicting ulnar variance, radial height, and inclination as well as the change in these parameters during treatment. Most important, VH ( $P = 0.001$ ) and age ( $P = 0.03$ ) were both predictive of carpal malalignment.

**Conclusion:** We were able to validate the McQueen equation and LaFontaine's criteria on radial height and inclination. However, neither method was predictive of final dorsal tilt or carpal malalignment. Hooking the volar cortex (restoring the volar cortical integrity) was the strongest predictor of final volar tilt, the change in volar tilt, and carpal malalignment at union. These data suggest that restoration of volar cortical alignment is an important predictor of success in nonoperative treatment of distal radius fractures.

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**MINI SYMPOSIA**

**Alternative Solutions in Post-Traumatic Reconstruction: I Need to Make Bone**

Moderator: *Samir Mehta, MD*

Faculty: *Stephen Kovach, MD; L. Scott Levin, MD; Stephen M. Quinnan, MD*  
and *Robert D. Zura, MD*

**Pediatric Polytrauma: Navigating Gator Country**

Moderator: *Charles T. Mehlman, DO, MPH*

Faculty: *Richard Falcone, Jr., MD* and *Steven L. Frick, MD*

**Management of Complex Elbow Trauma**

Moderator: *Kagan Ozer, MD*

Faculty: *Jeffrey F. Lawton, MD* and *Rick Papandrea, MD*

NOTES



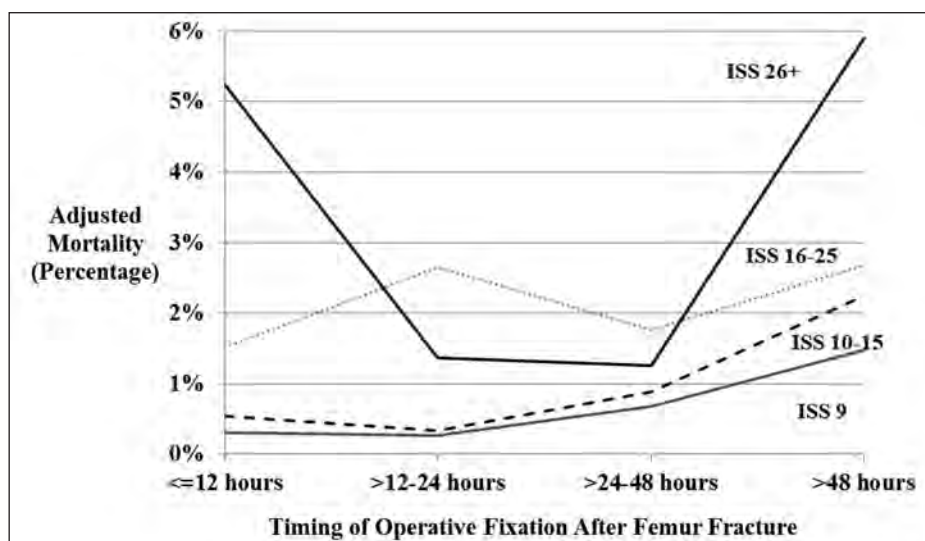
## Optimal Timing for Femoral Shaft Fracture Fixation Depends on Injury Severity Score and Age

Sara C. Graves, MD; Robert Victor Cantu, MD; Kevin F. Spratt, PhD;  
Dartmouth Hitchcock Medical Center, Lebanon, New Hampshire, USA

**Purpose:** Optimal surgical timing for definitive treatment of femur fractures in severely injured patients remains controversial. This study was performed to examine in-hospital mortality for patients with femur fractures with regard to surgical timing, ISS, and age.

**Methods:** The National Trauma Data Bank–version 7.0 was used to evaluate in-hospital mortality for patients presenting with unilateral femur fractures relative to timing, ISS, and age, adjusting for patient health, injury, and personal demographics. Patients were stratified into 4 groups by surgical timing (ST1  $\leq$ 12 hours, ST2 >12-24 hours, ST3 >24-48 hours, and ST4 >48 hours to 30 days) and 4 groups by ISS (ISS = 9, 10-15, 16-25, and 26+). Chi-square tests evaluated baseline interrelationships of timing and ISS with other predictors. Poisson regression estimated unadjusted and adjusted in-hospital mortality rates and relative risks (RR) associated with timing and ISS classification.

**Results:** 7540 patients met inclusion criteria with a 1.4% overall in-hospital mortality rate. For patients with an isolated femur fracture, delaying surgery >48 hours was associated with a 5 times greater mortality compared to surgery within 12 hours (adjusted RR 4.8 [95% confidence interval, 1.6-14.1]) The only group that had lower mortality with a delay in surgery was the most severely injured patients (ISS 26+), who had 4 times lower mortality if surgery was performed between 12 and 48 hours rather than being performed within the first 12 hours (adjusted RR 4.2 [95% confidence interval, 1.0-16.7], adjusted absolute



**Figure 1.** Adjusted Mortality Rates by Injury Severity Score and Timing of Operative Fixation after Femur Fracture.

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mortality rates of 5.2 vs. 1.3%). The association between higher mortality rates and surgical delay beyond 48 hours was even stronger in elderly patients.

**Conclusions:** This study supports the work of prior authors who reported that early definitive fixation of femur fractures is beneficial, but also is consistent with more recent studies recommending at least 12 to 24 hours delay in fixation in severely injured patients to promote better resuscitation. Delay of definitive care beyond 48 hours was associated with higher mortality rates, particularly in the elderly.

### Six Years' Experience With the Reamer-Irrigator-Aspirator: Impact on Healing and Pulmonary Complications Rates in Femoral Shaft Fractures

*Anthony J. Bell, MD; Pratik P. Desai, MD; Michael Suk, MD, JD, MPH;*

*University of Florida College of Medicine—Jacksonville, Department of Orthopaedic Surgery, Jacksonville, Florida, USA*

**Background/Purpose:** Sequentially reamed, locked intramedullary nails are the standard of care for femoral diaphysis fractures. The reamer-irrigator-aspirator (RIA) has been theorized to minimize known perioperative pulmonary complications of sequentially reamed intramedullary nails such as fat embolism syndrome (FES) and acute respiratory distress syndrome (ARDS) in the polytraumatized patient. It has been postulated that while using the RIA system may have a protective effect for the trauma patient, there may be a deleterious effect on bone healing versus conventional reaming due to aspiration of osteogenic cells and material. This study was conducted to report on healing and pulmonary complication rates of femur fractures treated using the RIA system versus conventional sequential reaming prior to the insertion of intramedullary nails.

**Methods:** A retrospective study was conducted comparing conventional sequentially reamed nailing for femur fractures versus those treated with the RIA. From January 2005 through December 2010, 422 patients who met inclusion criteria were treated at our Level I trauma center with an intramedullary nail by one of three fellowship-trained orthopaedic trauma surgeons. There were 283 patients with 291 femur fractures treated with conventional reaming (group A), and 139 patients with 147 femur fractures treated with the RIA (group B). The main outcome measures included rate of pulmonary complications including ARDS, pneumonia, ventilatory failure, overall pulmonary complications, days on ventilator, length of hospital stay, healing rate, and death.

**Results:** No significant differences were found between groups with regard to patient demographics, ISS, the incidence of head / chest trauma, time to surgery, surgical time, or the distribution of fractures according to the OTA femur fracture classification. In addition, no differences were found in length of hospital stay, length of ICU stay, or time on mechanical ventilation. Overall pulmonary complications occurred in 19% (group A) and 23% (group B), respectively ( $P = 0.47$ ). Two fatalities were found in group A with four in group B ( $P = 0.18$ ). A significant difference was found in healing rates between the groups with higher rates of delayed union and nonunion in the RIA group. Overall healing complications were seen in 3% and 11% of patients ( $P = 0.002$ ) in groups A and B, respectively.

**Conclusion:** No statistical significance was reached with regard to pulmonary complications or death. We were unable to demonstrate a favorable pulmonary effect with RIA use compared to conventional reaming as has been described in previous animal studies. We found a significant difference increase in healing complications in the RIA group as compared to the sequential reaming group.

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**Duration of Fracture Fixation Surgery in Multitrauma Patients***Christopher E. Mutty, MD; Lars M. Qvick, MD; Mark J. Anders, MD;**Cathy M. Buyea, MS; Lawrence B. Bone, MD;**State University of New York at Buffalo, Erie County Medical Center, Buffalo, New York, USA*

**Purpose:** Early orthopaedic surgery in the multiply injured patient has been reported to have a safe upper limit of 2 hours. A review of the literature reveals evidence of a 6-hour limit; however, no evidence was found for the 2-hour time constraint. We hypothesized that length of early surgery time would not be associated with patient outcome. Standard of care at our institution requires ongoing resuscitation and careful monitoring of patient status for surgery to continue as long as the patient is stable.

**Methods:** University IRB approval was obtained and a report was requested from the institutional trauma database of all multitrauma patients presenting with an ISS of  $\geq 18$  from January 2007 to May 2011. This report contained 1690 patients with 232 orthopaedic injuries; of these, 187 had long bone injuries and were included in the analyses. Data were analyzed with independent  $t$  tests for continuous variables and  $\chi^2$  or Fisher exact test for categorical. Logistic regression analysis was used to determine predictors of mortality and acute respiratory distress syndrome (ARDS). A power analysis revealed that with alpha at 0.05 and 153 cases, we could determine a difference in odds of 1.5 with 80% power.

**Results:** There were no significant associations found with total minutes of surgery and pulmonary complications nor were there any significant associations found with surgery as a categorical value (<2,  $\geq 2$  hours; 1 to <3, 3-6, >6). Length of surgery was not a significant predictor of mortality ( $P = 0.45$ ) or ARDS ( $P = 0.75$ ).

**Conclusion:** This series of patients suggests duration of surgery alone need not limit early orthopaedic trauma procedures in the multiply injured patient.

Surgery Time	Mortality	ARDS	Pneumo- thorax	Acute Respiratory Failure	Pulmonary Collapse	Acidosis	Pneumonia
	D   L	Y   N	Y   N	Y   N	Y   N	Y   N	Y   N
<2 hours	5 85	9 81	36 54	9 81	2 88	1 89	8 82
≥2 hours	3 94	11 86	29 68	10 87	6 91	2 95	6 91
<i>P</i>	0.41	0.77	0.15	0.94	0.33	0.99	0.48
1 to <3 hours	7 119	13 113	47 79	12 114	3 123	2 124	9 117
3-6 hours	1 52	7 46	15 38	6 47	5 48	1 52	5 48
>6 hours	0 8	0 8	3 5	1 7	0 8	0 8	0 8
<i>P</i>	0.61	0.68	0.54	0.75	0.13	0.99	0.77

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## Risk of Obtaining Routine Cultures During Presumed Aseptic Orthopaedic Procedures

*Matthew A. Napierala, MD; Jaime L. Bellamy, DO; Clinton K. Murray, MD; Joseph C. Wenke, PhD; Joseph R. Hsu, MD; Skeletal Trauma Research Consortium (STRc); San Antonio Military Medical Center, Fort Sam Houston, Texas, USA*

**Background/Purpose:** Infection has been well established as a contributing factor to non-union, as well as the need for other secondary procedures. For this reason, many surgeons perform intraoperative cultures routinely even when there is no suspicion of infection. The results of these routine cultures may lead to antibiotic treatment and the risk of subsequent antibiotic complications without reducing the rate of infection. To our knowledge, there are no studies evaluating the morbidity involved with obtaining routine intraoperative cultures. We hypothesize that the use of routine cultures leads to an increased rate of adverse effects without a decreased rate of deep infection.

**Methods:** All patients who underwent bone grafting for presumed aseptic nonunions, presumed aseptic heterotopic ossification excision, presumed aseptic symptomatic hardware removal, and presumed aseptic amputation revision at our institution between March 2005 and June 2008 were identified using surgical and inpatient databases. Within this cohort, four groups were identified. Group 1 included patients with positive routine cultures who were subsequently treated with antibiotics; group 2 included patients with positive routine cultures who were not treated with antibiotics; group 3 included patients in which routine cultures were negative; and group 4 included patients in which no routine cultures were obtained. We then used inpatient and outpatient records to tabulate all patients who were rehospitalized for a late deep infection or antibiotic complication. Late deep infection was defined as infection requiring rehospitalization or reoperation. The groups were then compared using  $\chi^2$  test with calculated 95% confidence intervals. Student t test was performed on all independent variables. Significance level was set at  $P < 0.05$  for all tests.

**Results:** 58 of the 162 included patients had routine cultures obtained (36%). Of those with routine cultures, 18 were positive (31%), while 40 cultures were negative (69%). Overall, 22 patients developed a late infection (14%). 7 of the 14 patients (50%) in group 1 (routine cultures positive, treated with antibiotics) developed a late infection (24%, 76%). 4 of the 18 patients (22%) in group 2 (routine cultures positive, no antibiotic treatment) developed a late infection (7%, 48%). 5 of the 40 patients (12.5%) in group 3 (routine cultures negative) developed a late infection (5%, 28%). 3 of the 104 patients (3%) in group 4 (no routine cultures obtained) developed a late infection (0.1%, 9%). The most common organism obtained on routine culture and causing late infection was *Klebsiella pneumoniae*. Of the 24 patients with positive routine cultures treated with antibiotics, a significant number of these patients (29%) experienced an antibiotic complication ( $P < 0.0001$ ) (14%, 54%), with 5 (21%) requiring rehospitalization specifically for their antibiotic complication (7%, 42%). The most common antibiotic complications were renal failure and neutropenia. Patients treated for an infection underwent a significantly increased number of invasive procedures than those not treated ( $P < 0.0001$ ).

**Conclusion:** Obtaining routine intraoperative cultures for presumed aseptic secondary orthopaedic procedures appears to lead to a high risk for antibiotic-related complications without reducing the rate of late deep infection.

See pages 97 - 144 for financial disclosure information.

**Rapid Polymerase Chain Reaction Test for Methicillin-Resistant *Staphylococcus aureus* in Orthopaedic Trauma**

*Holman Chan, MD; John P. Ketz, MD; Catherine A. Humphrey, MD; Jonathan M. Gross, MD; Robert F. Betts; John T. Gorczyca, MD;*  
*University of Rochester Medical Center, Rochester, New York, USA*

**Purpose:** This study was conducted to (1) evaluate the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) colonization in orthopaedic trauma patients; (2) identify risk factors for MRSA colonization in orthopaedic trauma patients; and (3) implement rapid polymerase chain reaction (PCR)-MRSA amplification to guide appropriate perioperative antibiotic prophylaxis. We hypothesized that the prevalence of MRSA colonization is higher than reported in earlier literature and that there are identifiable risk factors in patient medical, surgical, and social history that predispose this select population. We also hypothesized that rapid PCR testing can be consistently implemented to help modify perioperative antibiotic prophylaxis.

**Methods:** Adult patients with a surgical orthopaedic injury admitted to a Level I trauma hospital were swabbed for a nasal specimen. This was then tested for MRSA colonization via a rapid PCR-MRSA amplification test validated for its efficient turnover compared with that of bacterial culture (4 hours versus 2 days, respectively). Patients who test positive as an MRSA carrier had their perioperative antibiotic prophylaxis adjusted to treat MRSA. Medical history for each patient was reviewed for age, gender, preexisting medical/surgical conditions, recent antibiotic use, and remote history of cancer and infection. Social history was reviewed for recreational drug use and recent exposure to the institutionalized and/or to medical personnel. Multivariate binary logistic regression was performed to identify risk factors associated with MRSA colonization.

**Results:** 326 consecutive patients with surgical orthopaedic injuries were admitted to the Level I academic trauma center and tested with rapid PCR during the study period. Of these 326 patients, 25 patients (7.7%) tested positive as MRSA carriers. 19 of the 25 patients (76%) had their perioperative antibiotics adjusted to vancomycin. Three of five (60%) patients with previous documented MRSA infections tested positive for MRSA colonization in this study.

The two most significant adjusted risk factors for MRSA colonization are current infection (odds ratio [OR] 19.5; 95% confidence interval [CI], 1.62-234) including urinary tract infections, cellulitis, and deep wound infections; and gastrointestinal conditions (OR 4.83; 95% CI, 1.31-17.8), including gastroesophageal reflux disease, gastrointestinal ulcers, and colitis. Other independent risk factors include obesity (OR 8.07; 95% CI, 1.81-36.0), previous exposure to the institutionalized and/or to medical personnel (OR 4.03; 95% CI, 1.47-11.0), chronic illness (OR 3.87; 95% CI, 1.68-8.92), diabetes mellitus (OR 3.79; 95% CI, 1.6-8.97), and the presence of medical implant such as a pacemaker, prosthetic joint reconstruction, or fracture fixation (OR 3.25; 95% CI, 1.41-7.51). Contrary to the results of certain other studies, age and recent antibiotic use did not demonstrate significant correlation with MRSA colonization in this study population.

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**Conclusions:** The preliminary results of this study suggest a higher prevalence of MRSA colonization in orthopaedic trauma patients encountered in this institution at 7.7% relative to the documented 3% to 5% in earlier literature. Rapid PCR amplification testing for MRSA can be instituted to direct appropriate perioperative antibiotic prophylaxis.



### **Conventional Compressive Dressings Superior to Negative-Pressure Dressings for Split-Thickness Skin Graft Coverage of Traumatic Extremity Wounds**

*Laurence B. Kempton, MD; Timothy Larson, MD; Harvey Montijo, MD; Stephen H. Sims, MD; Madhav A. Karunakar, MD; Stanley Getz, MD; James F. Kellam, MD, Michael J. Bosse, MD; Carolinas Medical Center, Charlotte, North Carolina, USA*

**Purpose:** Negative-pressure dressings (NPDs) are commonly used to cover split-thickness skin grafts (STSGs) due to their reported high success with graft healing. Multiple clinical studies have shown their efficacy; however, they have not been proven to be superior to conventional compressive dressings (CDs). Our purposes were to determine whether there is any difference in clinical outcomes of STSGs when using an NPD versus CD and to determine the average cost difference at our institution between these two dressing types.

**Methods:** We reviewed charts for all patients who underwent STSG surgery for extremity wounds from 2006 to 2010 by five surgeons (four orthopaedic trauma surgeons and one plastic surgeon). STSG splaced on flaps and burn wounds were excluded. All patients either received an NPD or a CD. Initial dressings were removed after 5 days, and the STSGs were rewrapped with a nonadherent dressing. Patients were assigned one of four possible outcomes based on postoperative documentation: completely healed, incompletely healed (any area of persistent drainage or small area of failed graft not requiring surgical intervention), failed (complete loss of the STSG or return to operating room for any reason related to the STSG), or lost to follow-up. To determine the cost differences between the dressing types, the costs associated with the dressings for the 5 postoperative days were compared.

**Results:** 35 of 195 STSG were lost to follow-up, leaving N = 120 STSG-NPD and N = 40 STSG-CD. Of the 120 STSGs treated with an NPD, 91 completely healed, 23 incompletely healed, and 6 failed. Of the 40 STSGs treated with a CD, 37 completely healed, 1 incompletely healed, and 2 failed. Using ordered logistic regression, patients treated with CDs had higher rates of healing (either complete or incomplete) relative to the NPD ( $P = 0.018$ ). Analyzing the outcomes as failed versus "not failed" (ie, either completely or incompletely healed) revealed no significant difference between the groups ( $P = 1.00$ ). There were no significant differences between the compared groups with respect to patient age, tobacco use, past medical history, body mass index, graft location, wound size, wound bed tissue type, cause of wound, or presence of associated infection. In this series, the mean cost associated with NPD compared to compressive dressing was \$2370 more per patient. No patients were readmitted to the hospital prior to the first dressing change in either group.

**Conclusions:** There is a high rate of successful healing of STSGs for traumatic extremity wounds. Despite the increased cost of NPD compared to CD, there was no improvement in clinical outcomes with the NPD in our population. STSGs receiving a CD had significantly higher rates of healing compared to those receiving NPDs.

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### Δ Utilization of Two Grading Systems in Determining Risks Associated With Fracture Fixation in Multiply Injured Patients

Nickolas J. Nahm, MD; Heather A. Vallier, MD; Timothy A. Moore, MD;  
MetroHealth Medical Center, Cleveland, Ohio, USA

**Purpose:** Early definitive treatment of femur, pelvis, and acetabulum fractures has been shown to reduce pulmonary complications and mortality in stable patients. Damage control orthopaedics (DCO) is a good option for unstable patients at high risk for systemic complications. A clinical grading system (Pape et al) and the early appropriate care (EAC) protocol have been suggested to characterize high-risk patients and to recommend DCO versus early fixation. This study applies each of these criteria to a cohort of multiply injured patients with femur, pelvis, acetabulum, and/or spine fractures to determine their utility in preventing complications potentially related to early definitive surgery in underresuscitated patients.

**Methods:** 744 patients with femur (n = 568), pelvis (n = 108), acetabulum (n = 90), and/or thoracolumbar spine (n = 19) fractures treated definitively within 24 hours of injury were reviewed. Patients were assigned a clinical condition based on previously defined clinical grading systems: Table 1 (Pape et al) and Table 2 (EAC). Best condition and worst condition analyses were conducted for the Pape criteria due to inherent ambiguities when applying the criteria. Patients were excluded from analysis of each grading system if they did not have all laboratory tests and vitals of interest within 12 hours of the start of surgery. Outcomes included pneumonia, sepsis, acute respiratory distress syndrome (ARDS), deep vein thrombosis, pulmonary embolism, organ failure, renal failure and mortality.

**Results:** Best condition analysis of the Pape criteria resulted in 737 stable and 3 borderline patients. A higher rate of renal failure was found in the borderline group (33.3% vs 1.5%,  $P = 0.048$ ). The worst condition analysis stratified patients into stable (n = 695), borderline (n = 30), unstable (n = 7), and in extremis (n = 8) groups. A higher mortality rate was found in the borderline group compared to the stable group (3.3% vs 0.3%,  $P = 0.005$ ). More pneumonia (47.5% vs 4.9%,  $P = 0.006$ ), organ failure (12.5% vs 0.1%,  $P = 0.023$ ), and deaths (25.0% vs 0.3%,  $P < 0.001$ ) were found in the in extremis group compared to the stable group. By EAC criteria, 104 of 110 patients (94.5%) were resuscitated adequately for early definitive treatment. The other 6 patients, who also received definitive treatment within 24 hours of injury, developed more ARDS (33.3% vs 1.9%,  $P = 0.014$ ) and renal failure (33.3% vs 1.9%,  $P = 0.014$ ). No differences were found for other complications.

**Conclusions:** The Pape criteria differentiate patients at high risk for systemic complications who may benefit from DCO. However, only 8 patients in the worst condition analysis and none in the best condition were in extremis and were at higher risk for complications. One borderline patient and no unstable patients had complications, indicating that more work may be required to clarify the criteria in order to account for all clinical presentations. Furthermore, the use of this complex grading system in the acute resuscitation period requires further study. The EAC protocol provides simple guidelines that effectively distinguish high-risk patients, with less than 2% of lower risk patients having complications after early surgery. Additional study may determine whether the EAC criteria are valid for the spectrum of patient injuries and comorbidities seen at a regional trauma center.

Δ OTA Grant

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**Table 1** Clinical grading criteria (Pape et al)

	Stable	Borderline	Unstable	In Extremis
Recommended treatment	Early	DCO	DCO	DCO
Criteria*				
Hemodynamics**				
Systolic blood pressure (mm Hg)	≥100	≥80 to <100	≥60 to <80	<60
Base excess (mEq/L)	≥-2.3	<-2.3 to ≥-4.5	<-4.5 to ≥-6	<-6
Lactate (mmol/L)	0.5 to <2.2	≥2.2 to <2.5	≥2.5 to <4.0	≥4.0
pRBCs transfused (on day of injury)	0 to ≤2	3 to ≤8	9 to ≤15	≥16
Coagulation				
Platelets (10 <sup>3</sup> /μL)	>110	>90 to ≤110	>70 to ≤90	≤70
Temperature				
Temperature (°C)	>34	>33 to ≤34	>30 to ≤33	≤30
Soft-tissue injury**				
Chest Abbreviated Injury Scale	0, 1, or 2	3	4	5
Moore abdominal score	0, 1, or 2	3	4	5
AO/OTA pelvis classification	None	A	B	C

\*At least 3 of 4 major criteria (hemodynamics, coagulation, temperature, or soft-tissue injury) are required to be placed in a clinical grade. If 3 or 4 major criteria are not met, the clinical grade with the 2 major criteria is assigned when possible. If only 1 major criterion is met for each clinical grade, an average clinical grade is determined.

\*\*Best condition analysis places patients in the lowest possible clinical grade for the hemodynamics and soft-tissue injury major criteria based on the respective subcriteria. Worst condition analysis places patients in the highest clinical grade. All patients in these analyses had at least a platelet value or temperature, at least one hemodynamic subcriterion, and all soft-tissue subcriteria.

**Table 2** Early appropriate care protocol

Criteria	Early Treatment*	DCO**
pH	≥7.25	<7.25
BE (mEq/L)	≥-5.5	<-5.5
Lactate (mmol.L)	<4.0	≥4

\*Must meet at least 1 criterion to be considered early treatment

\*\*Must meet all 3 criteria to be considered DCO

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**The Influence of Insurance Status on the Surgical Treatment of Acute Spinal Fractures***Michael C. Daly, MSc; S. Samuel Bederman, MD, PhD, FRCSC;**University of California, Irvine Medical Center, Department of Orthopaedic Surgery, Orange, California, USA*

**Background/Purpose:** Fractures to the spinal column can be devastating injuries and those associated with spinal cord injuries are frequently treated emergently. Spinal fractures are often treated with surgical management based on fracture stability and the presence of neurologic involvement. Other factors, apart from fracture location, the presence of spinal cord injury, or other associated injuries may influence the decision for surgical intervention. It is poorly understood how nonclinical factors, such as insurance status, influence the decision for surgical intervention in these injuries. The purpose of this study was to determine the influence of insurance status on the rate of surgical intervention for acute cervical and thoracolumbar spine fractures with and without neurologic deficit.

**Methods:** Using data from the National Trauma Data Bank collected from January 2008 through December 2009, we included all patients age 18 to 64 who sustained a fracture of the cervical or thoracolumbar spine. Patients were excluded if they were dead on arrival or died in the emergency department, or if they sustained polytrauma (ISS  $\geq 27$ ) or a major injury (Abbreviated Injury Scale severity  $\geq 3$ ) to the head, thorax, or abdomen. Our main outcome measure was operative versus nonoperative treatment; our main predictor was insurance status. We analyzed baseline variables using bivariate statistics for our unadjusted comparisons. To control for the observed confounders in our adjusted comparisons, we calculated a propensity score representing the likelihood of each patient having insurance. Propensity scores were derived from a multivariable logistic regression model controlling for clinical (fracture location, spinal cord injury, comorbidities, demographics, mechanism of injury, and injury severity) and nonclinical factors (transfer status and hospital characteristics). Using hierarchical multivariable logistic regression models to account for clustering by hospital facility, we determined adjusted odds ratios (OR) for rate of surgery controlling for propensity score, insurance status, and clinical and nonclinical factors.

**Results:** We identified 40,316 spine fracture patients (mean age 40 years, 69% male, 77% white). In our unadjusted comparisons, surgery was associated with insurance (OR: 1.29,  $P < 0.0001$ ) and spinal cord injury (OR: 8.71,  $P < 0.0001$ ), as well as cervical (OR: 1.25,  $P < 0.0001$ ) and multilevel (OR: 1.13,  $P = 0.0080$ ) fractures relative to thoracolumbar fractures. After accounting for clustering by hospital and controlling for propensity score and hospital non-profit status, hierarchical logistic regression models demonstrated significantly higher rates of surgery in patients with insurance (OR: 1.31,  $P < 0.0001$ ), spinal cord injury (OR: 10.40,  $P < 0.0001$ ), blunt trauma (OR: 4.83,  $P < 0.0001$ ), shock (OR: 1.51,  $P < 0.0001$ ), younger age (OR: 1.004,  $P = 0.0023$ ), higher Glasgow Coma Scale score (OR: 1.02,  $P = 0.0135$ ), transfer from lower acuity hospital (OR: 1.62,  $P < 0.0001$ ), and those treated at teaching hospitals (OR: 1.41,  $P = 0.0428$ ). Race, gender, comorbidity, and fracture location were not statistically associated with higher surgical rates. Multivariable subgroup analysis of patients with spinal cord injury similarly revealed higher surgical rates for insured patients (OR: 1.32,  $P = 0.0331$ ).

**Conclusions:** Patients with traumatic spine fractures were more likely to receive surgery if they were insured, regardless of the presence of neurologic injury or fracture location. Further studies are needed to identify potentially modifiable factors influencing the decision for surgery and improve disparities in the delivery of health-care services.

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**Prevalence of Vitamin D Insufficiency in Orthopaedic Trauma Patients**

*Brett D. Crist, MD, FACS; Michael A. Hood, MD; Gregory J. Della Rocca, MD, PhD; James P. Stannard, MD; David A. Volgas, MD; Yvonne M. Murtha, MD; University of Missouri, Columbia, Missouri, USA*

**Purpose:** This study was conducted to determine the prevalence of vitamin D deficiency or insufficiency in orthopaedic trauma patients.

**Methods:** A retrospective medical record review was done of all orthopaedic trauma patients above the age of 18 years managed at a university Level I trauma center from January 1, 2009 to September 30, 2010 to identify patients that had a documented 25-hydroxyvitamin D level. Vitamin D deficiency was defined as a 25-hydroxyvitamin D level of less than 20 ng/mL and insufficiency was defined as a level between 20 and 32 ng/mL.

**Results:** 889 of 1830 patients had a documented 25-hydroxyvitamin D level. Vitamin D deficiency had an overall prevalence of 39%. Combined deficiency and insufficiency had an overall prevalence of 77.4%. 18- to 25-year-olds had the lowest prevalence of deficiency at 29.1% ( $P = 0.25$ ) and insufficiency at 54.7% ( $P = 0.08$ ). 36- to 55-year-olds had higher prevalence of deficiency and insufficiency but not statistically significant. Females aged 18 to 25 had lower prevalence of deficiency (25%,  $P = 0.41$ ) and insufficiency (41.7%,  $P = 0.16$ ) among females. Males aged 18 to 25 had a lower prevalence of insufficiency (59.7%,  $P = 0.24$ ) among males.

**Conclusions:** Vitamin D deficiency and insufficiency were prevalent in this large population of orthopaedic trauma patients. This is the largest known patient population of orthopaedic trauma patients to be evaluated for vitamin D deficiency. Our study time frame of 21 months helps account for seasonal variation in the prevalence of vitamin D deficiency. Establishing the incidence of vitamin D deficiency in a trauma population raises awareness of the disease, and should change screening and treatment patterns.

## The Cost Effectiveness and Utility of Trauma Center Care Following Major Lower Extremity Trauma

Herman S. Johal, MD, MPH<sup>1</sup>; Ellen J. MacKenzie, PhD<sup>2</sup>;

<sup>1</sup>University of Calgary, Health Sciences Centre, Calgary, Alberta, Canada;

<sup>2</sup>Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA

**Purpose:** This study was conducted to estimate the 1-year and lifetime treatment costs, incremental cost effectiveness, and incremental cost utility of treatment at a Level I trauma center compared with that of treatment at a non-trauma center for patients with major lower extremity injuries.

**Methods:** Secondary analysis was conducted on a US dataset from the National Study on Costs and Outcomes of Trauma (NSCOT), a multi-institutional, prospective study that examined the costs and outcomes of care received by 5191 adult trauma patients. NSCOT data were collected from 18 Level I trauma centers and 51 non-trauma centers located in 14 US states. Patients were recruited during an 18-month period (July 1, 2001 to November 30, 2002). Patients were taken from those eligible for the NSCOT parent study. This analysis included 1389 patients between 18 and 84 years of age, presenting to 1 of the 69 NSCOT institutions and having at least one lower extremity injury with an Abbreviated Injury Scale (AIS) score  $\geq 3$ . Cost data were derived from Medicare and Medicaid Services, hospital bills, and patient interviews. Cost-effectiveness was estimated as the ratio of the difference in costs over the difference in life years gained. Cost utility was measured as the cost per quality-adjusted life year (QALY) gained, using outcome data from the SF-6D. All analysis was performed with the use of data weighted back to the original population meeting inclusion criteria, which when applied to the sample of 1389 patients yielded a study population of 4619 patients. Inverse probability of treatment weighting was also used to adjust for observable differences in patients and case mix variation between trauma centers and non-trauma centers. Ratios of incremental costs and incremental effectiveness were derived for all patients, and separately for subgroups defined by high versus low energy and age. Cost-effectiveness acceptability curves (CEACs) were used to quantify and represent estimate uncertainty.

**Results:** The added cost for treatment in a trauma center compared to a non-trauma center for patients with major lower extremity injuries was \$1,901,287 per life saved, \$105,455 per life-year gained, and \$63,538 per QALY gained. Cost-effectiveness and cost utility were more favorable for lower extremity injuries resulting from high-energy versus low-energy mechanisms, and for younger versus older patients.

**Conclusions:** Regionalization of orthopaedic trauma care is effective and also cost effective for younger patients and those who sustain high-energy lower limb trauma.

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### Operating Room Efficiency: Benefits of an Orthopaedic Traumatologist at a Level II Trauma Center

*Peter L. Althausen, MD, MBA; Daniel John Coll, MHS, PA-C; Timothy J. O'Mara, MD; Timothy J. Bray, MD; Reno Orthopaedic Clinic, Reno, Nevada, USA*

**Purpose:** OTA fellowship survey data have suggested recent fellowship-trained orthopaedic trauma graduates are having difficulty obtaining "first choice" employment positions at the time of graduation. This new market dynamic represents changes in employment opportunities, hospital-based saturation of trauma positions, disinterest in private practice models, and declining reimbursement formulas. Fellowship-trained orthopaedic traumatologists (FTOTs) are taught skill sets that result in "best practice" outcomes and more efficient use of hospital resources that result in more favorable economic opportunities when compared to general orthopaedic surgeons (GOS) providing similar clinical services. The purpose of our study was to compare the operating room utilization and outcome data of FTOTs versus GOS. The data can be used to convince hospital systems committed to the trauma mission that they should continue hiring FTOTs knowledgeable in supply chain management (SCM).

**Methods:** Our institutional database was queried to identify all orthopaedic fracture cases performed at our institution from January 2009 to January 2010. Operative records were reviewed to determine time to operating room (OR), operative times, estimated blood loss (EBL), and intraoperative complications. Patients were stratified according to those treated by our trauma panel's three FTOTs and those treated by the 18 other orthopaedic surgeons on our trauma panel. These two groups were then compared using standard statistical methods.

#### Results:

	OR Time, min	OR Time, min	LOS, days	LOS, days
Surgery Type	General	Trauma	General	Trauma
Clavicle ORIF	60	35	NA	NA
Distal radius ORIF	95	34	NA	NA
Distal humerus ORIF	120	60	NA	NA
Proximal humerus ORIF	90	40	NA	NA
Pelvis ORIF	240	90	7.4	4.8
Acetabular ORIF	300	90	9.8	5.4
CRPP femoral neck	30	9	5.8	3.6
Hip hemiarthroplasty	70	40	6.2	3.8
Hip nail	90	20	5.3	3.4

See pages 97 - 144 for financial disclosure information.



	OR Time, min	OR Time, min	LOS, days	LOS, days
Femoral nail	110	30	3.9	2.2
Patella ORIF	120	45	NA	NA
Tibial plateau ORIF	150	60	5.4	3.2
Tibial nail	120	45	3.5	2.0
Ankle ORIF	90	35	NA	NA

LOS, length of stay; ORIF, open reduction and internal fixation; CRPP, closed reduction and percutaneous pinning

**Conclusions:** This study demonstrates that at our community-based trauma system fracture care provided by FTOTs results in improved utilization of hospital-based resources when compared with equivalent services provided by GOS. Decreased operative times, shorter time to the OR, decreased LOS, and reduced complication rates by the fellowship-trained group represent enhanced control of the design, plan, execution, and monitoring (SCM) of orthopaedic trauma care. By creating increased “net value” to the hospital, newly trained orthopaedic traumatologists can use these data to negotiate more favorable employment contracts with “trauma-friendly” provisions for daytime ORs, physician assistants, equipment, and administrative assistance.

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## The PROMIS Physical Function Computerized Adaptive Test Is as Reliable and Valid as the Short Musculoskeletal Function Assessment in the Orthopaedic Trauma Population With Less Ceiling Effect

*Man Hung, PhD; Thomas F. Higgins, MD; Charles L. Saltzman, MD; Ami R. Stuart, PhD; Shirley Hon; Stefan Rhodewalt; Ashley M. Woodbury, BS; Gregory M. Daub, BS; Erik N. Kubiak, MD;*

*University of Utah Department of Orthopaedic Surgery, Salt Lake City, Utah, USA*

**Background/Purpose:** Understanding the outcomes of treatment is a fundamental step toward improving care of patients. Patient-reported outcomes have been recognized as critically important to guiding treatment decisions and assessing the effectiveness of clinical interventions. For orthopaedic trauma patients, the Short Musculoskeletal Function Assessment (SMFA) is a commonly used questionnaire to determine effectiveness of treatment and has been recommended by the American Academy of Orthopaedic Surgeons. It has been shown to demonstrate excellent internal consistency, content and convergent validity, reliability, and responsiveness. More recently developed is the Patient-Reported Outcomes Measurement Information System Physical Function Computerized Adaptive Test (PROMIS PF CAT) v.1, which dynamically administers questions from an item response theory (IRT)-calibrated bank of 124 questions. Based on the previous response to a question, the CAT selects the most relevant next question to administer. The PROMIS CATs have been shown to be highly reliable while drastically shortening the number of questions required to complete the questionnaires. This study seeks to compare the usability of the PROMIS PF CAT and SMFA in terms of floor and ceiling effects, reliability, and administration time.

**Methods:** Orthopaedic trauma patients who were seen for operative follow-up or non-operative fracture care and consultation were invited to participate in this IRB-approved study. When the patient arrived for his or her clinic visit, he or she was asked to consent to participation in the study by a research assistant. Upon receipt of consent, participants' basic demographic information was recorded. The patient was then given an iPad to complete the SMFA and the PROMIS PF CAT. Standard descriptive statistics such as means, standard deviations, frequencies, and patterns were used to describe patient demographic characteristics. Advanced psychometric techniques were used to evaluate the PROMIS PF CAT and the SMFA. In particular, we used a one-parameter Rasch IRT model to examine the psychometric properties of the instruments. We also calculated the average time required for each patient to complete the instruments.

**Results:** 153 patients participated in the study. Of those 55.7% were male, 81% self-identified as White, and 11.1% Hispanic or Latino; 53.2% had private insurance, 8.5% had Medicaid, and 22.7% had Medicare. On average, each patient had responded to 4 questions from the PROMIS PF CAT, and responded to all 46 questions from the SMFA. The mean administration time was significantly less for the PROMIS PF CAT than for the SMFA ( $P < 0.05$ ), 44 seconds and 599 seconds respectively. Both instruments showed an extremely high item reliability (Cronbach alpha of 0.98). In terms of instrument coverage, neither instrument showed any floor effect; however, the SMFA revealed 14.4% ceiling effect while the PROMIS PF CAT had none.

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**Conclusion:** Administered by electronic means with one question automatically advanced per page, the PROMIS PF CAT required less than one-tenth the amount of time than the SMFA for patients to complete while achieving equally high reliability as the SMFA. The PROMIS PF CAT also showed desirable psychometric properties while the SMFA shows some restrictions in the upper end of the physical function continuum, which can be problematic for assessing changes in outcomes. This improved instrument coverage and diminished time for patient completion may make the PROMIS PF CAT potentially more effective and useful than the SMFA for both clinical and research purposes. Further study may be needed to examine responsiveness to change of the PROMIS PF CAT over time.

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## Epidemiology of Vascular Complications in Supracondylar Humerus Fractures in the United States

Joshua Roehrich, MD<sup>1</sup>; Charles T. Mehlman, DO, MPH<sup>2</sup>, Jun Ying, PhD<sup>1</sup>;

<sup>1</sup>University of Cincinnati, Cincinnati, Ohio, USA;

<sup>2</sup>Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA

**Background/Purpose:** Supracondylar humeral fractures are the most common pediatric elbow fracture and may be associated with vascular complications. The purpose of our research was to analyze the incidence of vascular complications associated with pediatric supracondylar humeral fractures in the United States using the KID (Kids' Inpatient Database from the Healthcare Cost and Utilization Project) from 1997 thru 2009. Among patients who sustain supracondylar humeral fractures in the United States, the incidence rates of compartment syndrome and arterial injury are 0.32% and 0.73%, respectively.

**Methods:** The three primary outcome measures that we defined as vascular complications include: compartment syndrome, arterial injury, and Volkmann's ischemic contracture. Additionally we searched for potential risk factors associated with vascular complications, including presence of concomitant fractures, concomitant nerve injury, age, gender, payer status, etc. The appropriate ICD-9 codes were used to identify variables of interest within the KID database. Multivariate analysis of KID datasets and multiple stepwise logistic regression were used for data analysis.

**Results:** Analysis of the KID database from 1997-2009 revealed a total of 48,936 patients with a diagnosis of a supracondylar humeral fracture after weighting the data to obtain a national estimate. The mean age of patients was 6 years old. Among the 48,936 patients with a supracondylar humeral fracture, 158 were diagnosed with compartment syndrome and 358 sustained an arterial injury, yielding incidence rates of 0.32% and 0.73%, respectively. The incidence of compartment syndrome was 1.73% (44 of 2533) in patients with an associated forearm fracture and 2.87% (41 of 1431) in patients with a concomitant nerve injury. The incidence of compartment syndrome increased to 3.4% (5 of 147) in patients with multiple injured nerves. The incidence of arterial injury in patients with a concomitant peripheral nerve injury was 6.78% (97 of 1431), 8.84% (13 of 147) when multiple nerves were injured, and 20% when the median nerve was injured. There were not enough patients with a diagnosis of Volkmann's ischemic contracture to be included in our study.

**Conclusion:** Our large database study confirms what previous authors and many practitioners consider to be the case—supracondylar humeral fracture patients who have concomitant forearm fractures or nerve injury have a higher risk of vascular injury. Our study is also the first to report the national incidence of arterial injury (~30 children per year in the US) and compartment syndrome (~13 children per year in the US) in pediatric supracondylar humeral fracture patients.

**Complications of Retained Hardware After Plate Fixation of the Pediatric Forearm***Bryan G. Vopat, MD; Peter G. Fitzgibbons, MD; Patrick M. Kane, MD;**Christopher J. Got, MD; Julia A. Katarincic, MD;**Rhode Island Hospital, Providence, Rhode Island, USA*

**Purpose:** The removal of plates and screws placed during fracture fixation for pediatric forearm fractures is an historically common but currently controversial procedure. In a recent survey, 40% of pediatric orthopaedic surgeons recommended routine hardware removal, despite evidence that it exposes children to risks such as refracture through empty screw holes. Our hypothesis is that retained hardware after plate fixation results in equal or less morbidity than surgical removal of implants in pediatric forearm fractures.

**Methods:** Billing records and operative reports were used to identify all children between the ages of 6 and 15 years who underwent plate fixation of a single or both-bone forearm fracture from 1999 and 2009 at a single institution. Patients were interviewed over the phone and a physician filled out a questionnaire with regard to their clinical course. Factors such as hardware complications, functional activity level, pain score, and clinical symptoms were analyzed. These data were used to establish rates of complication between patients who had hardware retained and patients who had their hardware removed.

**Results:** Between 1999 and 2009, 58 patients (59 forearms) between the ages of 6 and 15 years who were treated with plate fixation for a forearm fracture were identified. Long-term follow-up was acquired for 33 of these patients. Average length of follow-up was 6.4 years (range, 1.5-10.1 years). Of the 33 patients, 6 had the plates electively removed while 27 patients initially elected to retain their hardware. Fractures occurred in 3 of 6 (50%) of the patients who chose to have their hardware electively removed versus 2 of 27 (7.4%) of the patients who chose to retain their hardware. Of the 27 patients who initially chose to leave the hardware in place, 3 of 27 (11.1%) had partial or complete removal of the hardware due to irritation. Additionally, patients with retained hardware reported the following symptoms: mild pain (10 of 27; 37.0%), clicking (10 of 27; 37.0%), ability to feel the plates (21 of 27; 77.8%), and mild weakness (9 of 27; 33.3%). However, significant functional improvement from injury was observed in this group, as 24 of 27 (88.9%) returned to preinjury level of activity and 26 of 27 (96.3%) reported being satisfied with their clinical outcome.

**Conclusion:** There is a decreased rate of refracture and, overall, a high level of satisfaction in those patients whose plates are left in place. Leaving forearm plates in place is a reasonable option in pediatric patients with forearm fractures.

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**Both-Bone Forearm Fractures in Children and Adolescents:  
Which Fixation Strategy is Superior? A Systematic Review***Keith D. Baldwin, MD, MSPT, MPH; Martin J. Morrison III, MD;**Lauren A. Tomlinson, BS; John M. Flynn, MD**The Children's Hospital of Philadelphia, Department of Orthopaedic Surgery,  
Philadelphia, Pennsylvania, USA*

**Background/Purpose:** Forearm fractures are a common injury in children and adolescents. There are many debates in the field of pediatric orthopaedics, including when to operate, what constitutes an acceptable reduction, and at what age does remodeling capability inherent to children become less effective. In general, the most common indications for surgical fixation in children and adolescents are open fractures, and the inability to maintain an acceptable closed reduction in a cast. Although operative management of these fractures has become increasingly more common over the last decade, the optimum fixation strategy is the subject of debate. The purpose of this study was to determine the difference in outcomes (union, complication rate, perioperative outcomes, and functional outcomes) of pediatric patients with a forearm fracture operatively treated with intramedullary nail fixation versus open reduction and plate fixation.

**Methods:** We performed a systematic review of the English literature for studies comparing plate and screw (P & S) fixation with intramedullary (IM) fixation in children and adolescents using computerized databases (PubMed, EMBASE, and Cochrane). Outcomes of interest were fracture union, complications, functional outcomes, perioperative variables, cosmesis, and need for hardware removal. We performed a meta-analysis using a DerSimonian and Laird random effects model. Publication bias and study quality were also assessed.

**Results:** 12 constituting 525 patients between the ages of 3 and 17 years were found. No differences were found between fixation strategies in terms of union or complications (total or major complications). Delayed unions and nonunions were rare, and slightly more common in the IM group, although the difference was not statistically significant. Refractures and scar-related problems were more common in the P & S group, and infection and hardware-related problems were more common in the IM group. Outcomes were excellent in nearly 9 of 10 patients regardless of fixation strategy. Operative time was greater in the P & S group as was cost. Cosmesis was superior in the IM group ( $P < 0.001$ ), and hardware removal was more common in the IM group ( $P < 0.001$ ).

**Conclusions:** IM nailing and P & S constructs are acceptable options in the fixation of pediatric forearm fractures. The literature fails to demonstrate a difference between IM fixation and P & S constructs. These results suggest that complication rates are similar, although the type of complication may vary. IM fixation provides improved cosmesis, but in general requires a second operation to remove hardware.

**SCRATCH (Self Cast Removal at the Child's Home): Treatment of Stable Pediatric Forearm Fractures Using Home Removable Casts Compared With Traditional Cast Therapy: A Prospective Randomized Controlled Trial**

*Thomas W. Hamilton, MBChB; Lynne Hutchings, MRCS; Jennie Wakefield; Joseph Alsousou, MRCS; Elizabeth Tutton; Emma Hodson; Clare Smith; Bridget Gray; Susanna Symonds; Keith M. Willett, MD; The Kadoorie Centre for Critical Care Research and Education, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, John Radcliffe Hospital, Oxford, United Kingdom*

**Purpose:** Pediatric forearm fractures are common. We hypothesized that home removable flexible casts in the management of stable forearm fractures in children is clinically equivalent to rigid cast management, more cost-effective than the hospital removal of a rigid cast, and acceptable to both the patient and parent.

**Methods:** 317 children aged 2 to 16 years with distal forearm torus, minimally angulated greenstick or nondisplaced stable epiphyseal fractures (OTA 23-M/2.1, E/1.1, and E/2.1), were enrolled in this single center prospective randomized controlled trial. Patients with a flexible (SoftCast 3M) below-elbow cast with home removal were compared to those with a fiberglass below-elbow cast with hospital removal. The primary outcome was change in Childhood Health Assessment Questionnaire (CHAQ) score from baseline to 1 week post cast removal. Secondary outcomes were change in CHAQ and EQ-5D from baseline to 6 months postinjury, change in EQ-5D baseline to 1 week post cast removal, user satisfaction, and cost-effectiveness of management.

**Results:** 159 children were randomized to flexible casts and 158 to fiberglass cast. There were two crossovers from flexible to rigid casts. Follow-up by postal questionnaire 1 week after cast removal was 74% and 91% at 6 months by telephone. 56% were male and 39% fractured their dominant arm. Mean age was 9.3 years (standard deviation 3.2 years). There was no significant difference between groups in demographics, injury characteristics, or baseline CHAQ and EQ-5D scores. No significant difference was seen in change of baseline CHAQ score to score 1 week post cast removal between either group after allocation for potential confounders ( $P = 0.245$ ). No significant differences were noted in CHAQ or EQ-5D scores at 6 months post injury in the flexible or rigid groups. The overall cost of treatment using home removable flexible casts was significantly less ( $P < 0.05$ ; \$246; range, \$231 to \$402) compared with standard cast therapy (\$400; range, \$385 to \$581). No difference was seen in satisfaction measures for both the cast and the general treatment between groups. Qualitative analysis identified that while the cast could be difficult to remove, there was a high level of satisfaction reported due to the convenience of home removal.

**Conclusion:** In children with stable distal forearm fractures, flexible below-elbow casts with home removal represent a safe, cost-effective alternative to traditional rigid fiberglass cast with hospital removal.

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## Do Any Factors Influence the Development of Femoral Head Osteonecrosis in Pediatric Femoral Neck Fractures?

Patrick M. Riley, Jr, MD<sup>1</sup>; Melanie A. Morscher, BS<sup>2</sup>; M. David Gothard, MS<sup>3</sup>;  
Patrick M. Riley, MD<sup>2</sup>;

<sup>1</sup>Summa Health System, Akron, Ohio, USA;

<sup>2</sup>Akron Children's Hospital, Akron, Ohio, USA;

<sup>3</sup>Biostats, East Canton, Ohio, USA

**Purpose:** Femoral neck fractures account for less than 1% of all pediatric fractures; however, femoral head osteonecrosis (ON) after this injury has been reported to range from 0% to 92%. The aim of this investigation was to add our experience to the literature and identify factors that may increase the risk of ON in pediatric patients with femoral neck fractures. We hypothesized that age, Delbet fracture classification, and time to reduction will affect the risk of ON in pediatric patients treated for femoral neck fractures.

**Methods:** An IRB-approved retrospective review identified 255 children with hip fractures treated at our institution from 1983 to 2009. Children were excluded if they had metabolic bone disease, subtrochanteric or pathologic fractures, slipped capital femoral epiphysis, or less than 1-year follow-up. This left 43 patients with 44 fractures in our study. Factors analyzed included age, Delbet fracture classification, time to reduction, displacement, reduction quality and type, and whether or not a decompression was performed. Fisher exact tests were used with  $P < 0.05$  considered statistically significant.

**Results:** Of the 44 cases included in the study, 9 (20%) developed ON. The rate of ON for Delbet type I fractures was 50% (2 of 4), type II was 28% (5 of 18), type III was 8% (1 of 12), and type IV was 10% (1 of 10). Age  $\geq 11$  years was the only statistically significant independent predictor of ON ( $P = 0.04$ ). There were no significant differences of ON rates between those undergoing early ( $\leq 12$  hours) or late reduction or those with or without capsular decompression. Further subanalysis of the age  $\geq 11$  years did not identify any other significant predictors; however, the difference in ON rates between those with open and closed reductions did trend towards statistical significance ( $P = 0.068$ ).

**Conclusion:** Our study of 44 femoral neck fractures is a relatively large case series with low ON rates (20%). Our data show that ON is more likely to develop in children  $\geq 11$  years of age. We were unable to demonstrate that early reduction ( $\leq 12$  hours) decreased ON rates when compared to reductions that were delayed.



## Salter-Harris II Fractures of the Distal Tibia: Does Surgical Management Reduce the Risk of Premature Physeal Closure?

*Franco Russo; Molly A. Moor, MPH; Scott J. Mubarak, MD; Andrew T. Pennock, MD; Rady Children's Hospital, San Diego, California, USA*

**Background/Purpose:** Premature physeal closure (PPC) is a common complication resulting from the management of a displaced Salter-Harris II (SH II) fracture of the distal tibia. The purpose of this study was to evaluate our institution's treatment approach to assess PPC and complication rates of fractures treated both surgically and nonsurgically.

**Methods:** We performed a retrospective review of all patients presenting with a displaced SH II fracture between 2004 and 2010. Initial treatment was closed reduction in the emergency department. Further treatment and subsequent categorization was based on amount of residual displacement. Patients with <2 mm of postreduction displacement were treated with a non-weight-bearing long-leg cast (LLC). Patients with residual displacement between 2 and 4 mm were treated with one of two approaches based on surgeon preference: (1) LLC or (2) open reduction and internal fixation (ORIF) with removal of any interposed tissue. Patients with >4 mm of residual displacement were treated with ORIF. Follow-up radiographs were performed for a minimum of 6 months. If there was clinical concern about PPC, CT imaging was performed to assess for a bony bar.

**Results:** In total, 96 patients with a mean age of 12.6 years at presentation were included in the study. Among the 14 patients with <2 mm of postreduction displacement, 29% had a PPC and 7% had to undergo a subsequent procedure. Of the 33 patients with 2 to 4 mm of displacement treated with a LLC, 33% had a PPC and 15% underwent a subsequent procedure. Of the 11 patients with 2 to 4 mm of displacement treated with ORIF, 46% had a PPC and 18% had a second procedure. Finally, 38 patients with >4 mm of displacement treated with ORIF had a PPC rate of 55% and 23% had a subsequent procedure. No statistically significant differences in PPC ( $P = 0.19$ ) or subsequent surgeries ( $P = 0.57$ ) were observed between groups. Among those with 2 to 4 mm of postreduction displacement, patient age ( $P = 0.36$ ), gender ( $P = 0.39$ ), mechanism of injury ( $P = 0.13$ ), time to fracture management ( $P = 0.51$ ), amount of initial displacement ( $P = 0.34$ ), number of reduction attempts ( $P = 0.43$ ), and operative treatment ( $P = 0.47$ ) did not significantly influence PPC.

**Conclusions:** Patients with displaced SH II distal tibia fractures pose a challenging problem for the treating physician with a high rate of PPC (42.7% overall). While surgical fixation with anatomic reduction and removal of interposed tissue may be necessary to improve joint alignment, it does not reduce the incidence of PPC and may increase the need for subsequent surgeries. We recommend closed treatment of SH II fractures unless surgery is necessary to improve joint alignment.

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## Character, Incidence, and Predictors of Knee Pain and Activity After Intramedullary Nailing of an Isolated Tibia Fracture

William T. Obremskey, MD, MPH<sup>1</sup>; Julie Agel, ATC<sup>2</sup>; Kristin Archer, PhD<sup>1</sup>;

Paul Tornetta III, MD<sup>3</sup>; for the SPRINT (Study to Prospectively evaluate Reamed Intramedullary Nails in Tibial fractures) Investigators;

<sup>1</sup>Vanderbilt University Medical Center, Nashville, Tennessee, USA;

<sup>2</sup>Harborview Medical Center, Seattle, Washington, USA;

<sup>3</sup>Boston Medical Center, Boston, Massachusetts, USA

**Purpose:** Knee pain is the most common complication following intramedullary nailing of the tibia with the incidence of knee pain reported to vary from 49% to 69%. The primary purpose of the study is to describe the incidence and predictors of knee pain in the large cohort of patients enrolled in the SPRINT (reamed vs unreamed intramedullary nails [IMNs]) study. A secondary goal is to compare impact on common activities of patients after an isolated tibia fracture.

**Methods:** The study included 437 patients from 30 sites who had an isolated tibia fracture treated with an IMN. 393 and 428 patients completed 6-month and 12-month assessments on pain, respectively. Self-reported activity at 12 months was completed by 390 patients for stairs outcome, 387 for kneel outcome, and 385 for run and walk prolonged outcomes. Self-reported activity at 12 months was completed by 390 patients for stairs outcome, 387 for kneel outcome, and 385 for run and walk prolonged outcomes. In addition to standard demographic information (age, sex, race, smoking status), injury characteristics (fracture location, wound type, fasciotomy, injury type, AO classification) and surgical technique (tendon approach, entry portal, nail type, and 2+ locking screws) were recorded. Knee pain was defined on a scale from 1 to 7, with 1 being “no pain” and 7 being a “very great deal of pain.” Knee pain >4 was considered clinically significant. Patients reported if they were “able,” “able with difficulty,” or “unable” to perform the following activities: stairs, kneel, run, walk prolonged. Variables that were significant in univariate analyses and a priori variables were tested in multivariable mixed-model regression analyses that included a random effect to control for the clustering of patients by site.

**Results:** 437 patients had a mean age of 41.9 years (standard deviation, 15.6); 71% were male. 76% were closed injuries and 9 (2%) had a fasciotomy. There were 19% midshaft, 8% proximal, and 73% distal fractures. The paratendinous approach was used in 77% of cases and a superior portal was used 75% of the time. *Knee pain:* Reaming did not influence knee pain so the remainder of the evaluations were performed across these groups. The percent of patients with a “good” to a “very great” deal of pain (>4) was 13% at 6 months and 11% at 12 months. 45% and 51% of patients reported “no” or “very little” pain at 6 and 12 months, respectively. At 12 months, smoking was the only risk factor for increased knee pain ( $\beta = 0.48$ ;  $P < 0.001$ ). *Activity at 12 months:* 45% and 26% of patients were “able with difficulty” or “unable” to kneel, respectively. For run, 37% of patients were “able with difficulty” and 29% were “unable.” The percent of patients who said they were “able with difficulty” or “unable” to climb stairs was 35% and walk prolonged was 31%. Female sex (odds ratio [OR] = 1.1;  $P = 0.01$ ) was a significant predictor of being unable to kneel at 12 months. Older age (OR = 1.01;  $P < 0.001$ ) and having a fasciotomy (OR = 1.6;  $P = 0.002$ ) were significant predictors

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of being unable to run. Risk factors for “able with difficulty” or “unable to perform” stairs and walk prolonged at 12 months were: stairs: older age (OR = 1.01;  $P = 0.001$ ), smoking (OR = 1.1;  $P = 0.01$ ), proximal fracture (OR = 1.2;  $P = 0.04$ ), and superior portal (OR = 1.1,  $P = 0.02$ ); walk prolonged: older age (OR = 1.01;  $P = 0.001$ ), smoking (OR = 1.2;  $P = 0.001$ ), and open fracture (OR = 1.2,  $P = 0.003$ ).

**Conclusion:** Clinically significant knee pain (>4 of 7) was present in 11% of patients 1 year after an isolated tibia fracture. An open fracture, fasciotomy, fracture location, and surgical technique did not predict pain at 12-month follow-up. Patient smoking was the most consistent factor that predicted knee pain. 26% to 45% of patients had difficulty performing or were unable to perform routine daily activities of kneeling, running, stair-climbing, or walking prolonged distances.

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## **Intramedullary Nailing of the Tibia via a Suprapatellar Approach: Radiographic Results and Clinical Outcomes at a Minimum of 12 Months Follow-up**

*Charles J. Jordan, MD; Thomas G. DiPasquale, DO; H. Claude Sagi, MD; John A. Arrington, MD; Roy Sanders, MD;*

*Orthopaedic Trauma Service, Florida Orthopaedic Institute, Tampa, Florida, USA*

**Background/Purpose:** Intramedullary (IM) nailing of the tibia has historically been performed through an infrapatellar approach with the knee flexed. Difficulty with fracture alignment and knee pain are known complications of this technique. A suprapatellar (SP) entry portal has been developed to allow positioning of the limb in a semiextended position, thus facilitating fluoroscopic imaging and maintenance of fracture reduction. Additionally, infrapatellar knee pain is reported to be decreased. The technique, however, remains controversial due to the necessity of instrument and implant insertion through the patellofemoral (PF) joint. The purpose of this study was to determine the incidence of both chondral damage to the PF joint and knee pain, knee range of motion (ROM), and fracture healing with the SP technique.

**Methods:** 40 consecutive patients (40 fractures) with an extra-articular tibia fracture confined to the middle 3/5 of the tibia (OTA 42A-C) underwent locked, reamed, SP IM nailing using specially designed instruments (Stryker Corp; Smith & Nephew) for this technique. All patients were skeletally mature. Patients were evaluated clinically and radiographically at 1, 3, 6, and 12-month intervals. Functional outcomes (Short Form 36 [SF-36], Lysholm knee score, visual analog pain (VAS), knee ROM, and a diagram documenting location of pain) were collected by an independent third party at 6 and 12 months. MRI of the knee was performed at 12 months, and independently reviewed by a board certified, fellowship-trained musculoskeletal radiologist.

**Results:** Patients were followed for a minimum of 1 year (range, 12-49 months). All fractures healed, and no angular or length deformity was seen. The median Lysholm knee score at final follow-up was 82.5 (range, 20-100). Mean SF-36 physical and mental component summary scores were 40.8 (standard deviation [SD] 9.7) and 46.0 (SD 11.7), respectively. Mean arc of knee motion was 121.3° (SD 15.5°) for the affected extremity compared with 125.9° (SD 17.5°) for the contralateral knee. 36 of 40 patients (90%) had no knee pain whatsoever. Four patients (10%) were found to have knee pain. Two patients had joint line pain (with known meniscal tears), and two patients had tenderness associated with a proximal locking screw). Importantly, no patients complained of PF joint pain. By MRI, no patients were found to have changes in the PF cartilage attributable to the surgical technique.

**Conclusion:** Our data from this prospective analysis indicate that an SP entry portal is a safe site for tibial nail insertion in the treatment of tibial shaft fractures. Knee pain secondary to damage to the PF cartilage did not occur, and was, in fact, significantly lower than that reported historically for the infrapatellar technique. Moreover, we were unable to demonstrate any deleterious effects on the articular cartilage of the PF joint with MRI at 1 year postprocedure. An OTA-sponsored randomized controlled trial is presently underway to further define the role of this technique for the management of OTA 42A-C fractures.

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### Intramedullary Nailing for Distal Tibial Fractures

*Christiane G. Kruppa, MD<sup>1</sup>; Martin F. Hoffmann, MD<sup>1</sup>; Michelle B. Mulder, BS<sup>2</sup>;  
Debra L. Sietsema, PhD<sup>3</sup>; Clifford B. Jones, MD<sup>3</sup>;*

<sup>1</sup>Grand Rapids Medical Education Partners, Grand Rapids, Michigan, USA;

<sup>2</sup>Wayne State University, Detroit, Michigan, USA;

<sup>3</sup>Orthopaedic Associates of Michigan, Michigan State University, Grand Rapids, Michigan, USA

**Background/Purpose:** Locked intramedullary nailing is considered the treatment of choice in diaphyseal tibial fractures. With accumulation of experience with tibial nails and the ability of multiplanar locking in varying directions, the indication for intramedullary nailing was gradually expanded to include more cases of distal tibial fractures. The difference in size between the implant diameter and the metaphyseal diameter results in small nail-cortex contact and diminished cortical bone support of the distal tibia limits the construct stability. The purpose of this study was to elucidate postoperative radiographic alignment, nonunion rates, and clinical outcome (range of motion) after intramedullary nailing for distal tibial fractures.

**Methods:** From 2002 to 2010, 239 consecutive patients with intramedullary nail-treated distal tibial fractures (<11 cm from the joint line, OTA 43) were retrospectively evaluated. Patients were followed in a single large private orthopaedic practice affiliated with a Level I trauma center. Excluded patients were related to initial amputation (1), existing ankle arthrodesis (1), no follow-up (10), and follow-up less than 10 months (105), as well as insufficient radiologic and chart data (17). Therefore, the final study group consisted of 105 distal tibial fractures. Injuries were classified as 52 A1, 13 A2, 9 A3, 25 C1, 5 C2, and 1 C3 according to the OTA/AO 43 classification. Comorbidities and risk factors were recorded. Patients were evaluated clinically (range of motion, pain, return to work) and radiographically at regular intervals of 2 weeks, 6 weeks, 12 weeks, 6 months, and 1 year. Varus/valgus and sagittal alignment were measured on the final radiographs.

**Results:** The study population consisted of 57 male (54.3%) and 48 female patients (45.7%), with 43 left (40.9%) and 62 right leg injuries (59.1%). Mean age was 43.1 years (range, 18-89). The body mass index averaged 27.3 kg/m<sup>2</sup>. Mean follow-up was 25.6 months (range, 10-74). The majority of the injuries were caused by high-energy trauma (61.9%), with 33 open fractures (31.4%). The average distance to the joint line was 6.1 cm (range, 0-10.9 cm). An accompanying fibula fracture was diagnosed in 101 and treated in 40 patients with plating (26) or rush pin (14). Nonunion occurred in 20 patients (19%). 33.3% of the nonunions occurred in open fractures ( $P = 0.14$ ). Nonunions were significantly associated with open fractures ( $P = 0.014$ ), wound complications ( $P < 0.001$ ), and fibular fixation ( $P = 0.007$ ). Hardware removal was performed in 52 patients (36 nails, 16 screws). Radiographic evaluation showed a mean AP angulation of 2.5° valgus, with 4 patients having >5° varus and 21 patients >5° valgus. The joint line in the lateral view averaged 88.6°. Range of motion averaged 15.1° (range, 0°-30°) of dorsiflexion and 37.9° (range, 3°-50°) of plantar flexion. Knee pain occurred in 24 patients. The average knee range of motion was 0° of extension and 140° of flexion (range, -10°-150°).

**Conclusion:** Intramedullary nailing of distal tibial fractures is a treatment option for specific indications. Stable fixation with good alignment and range of motion can be achieved. A nonunion rate of 19% is high. Nonunions were significantly associated with open fractures, wound complications, and fibular fixation.

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## Validation of the OTA Open Fracture Classification With Data From a Prospective Cohort Study of Limb-Threatening Tibia Fractures

Clifford B. Jones, MD<sup>1</sup>; Renan C. Castillo, PhD<sup>2</sup>; Anthony R. Carlini, MS<sup>2</sup>; Debra L. Sietsema, PhD, RN<sup>1</sup>; MAJ Kenneth J. Nelson, MD<sup>3</sup>; LTC Anthony E. Johnson, MD<sup>3</sup>; Michael J. Bosse, MD<sup>4</sup>; Ellen J. MacKenzie, PhD<sup>2</sup>; for the LEAP (Lower Extremity Assessment Project) Study Group;

<sup>1</sup>Orthopaedic Associates of Michigan, Michigan State University, Grand Rapids, Michigan, USA;

<sup>2</sup>Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA;

<sup>3</sup>Brooke Army Medical Center, San Antonio, Texas, USA;

<sup>4</sup>Carolinas Medical Center, Charlotte, North Carolina, USA

**Purpose/Hypothesis:** The OTA Open Fracture Study Group recently developed a new open fracture classification system to facilitate consistent application and communication in assessment, treatment, and research. The new OTA Open Fracture Classification (OFC) includes five assessment categories: skin, muscle, arterial, contamination, and bone loss, and each category is subdivided into three descriptors of increasing severity. However, the classification has not been fully validated. The goal of this study was to use data from a prospective cohort study of severe limb-threatening tibia injuries to assess the validity of the OFC.

**Methods:** 347 open tibia fractures (including severe IIIA and all IIIB and IIIC) were retrospectively classified with respect to the OFC by the investigators, based on the available cohort study data. The main outcome measure was amputation. Among limb salvage patients, the main outcome measure was the Sickness Impact Profile (SIP), a gold standard measure of functional outcome, measured at 2 years postinjury. Changes in the SIP of 3 points or more have been shown to represent clinically important differences. Bivariate and multiple variable regression analysis techniques were used to study the relationship between the OFC and these outcomes.

**Results:** Correlations between the five OFC components were only moderate to low, ranging between 0.05 and 0.53. An increased severity of each OFC component score was significantly associated with amputations: skin, muscle, and arterial  $\chi^2 P < 0.0001$  for all three; contamination  $\chi^2 P = 0.0002$ ; and bone loss  $\chi^2 P = 0.0052$ . The predictive power of each OFC component with respect to amputation, as measured by predictive area under the curve (AUC), was comparable to that of the Gustilo-Anderson classification. AUCs for the five OFC components ranged between 0.55 and 0.76, compared to 0.42 to 0.71 for the Gustilo classification. Among salvage patients, having the highest level of the muscle, bone loss, and arterial OFC component was associated with a 2.9, 3.8, and 5.8-point increase in disability at 2 years. A combination criterion of the highest levels of the arterial and bone loss components was developed, which occurred in 23% of this severely injured population. These criteria predicted a 4.5-point increase in disability (95% confidence interval: 0.2, 8.7;  $P = 0.04$ ).

**Conclusions:** There is a need to improve and refine the methodology of open fracture classification to guide injury description and stratification. The new OTA OFC provides a system to classify soft-tissue injuries along five clinically significant components. The data show

that these components are not correlated at such a high level as to be considered redundant and are all strongly predictive of amputation—a major clinical outcome. Furthermore, the data suggest several OFC components may be associated with clinically and statistically significant differences in long-term functional outcome.

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### Soft-Tissue Injury Predictors of Amputation Following Severe Open Tibia Fractures

MAJ Kenneth J. Nelson, MD<sup>1</sup>; LTC Anthony E. Johnson, MD<sup>2</sup>; Clifford B. Jones, MD<sup>3</sup>;

Renan C. Castillo, PhD<sup>4</sup>; Anthony R. Carlini, MS<sup>4</sup>; Michael J. Bosse, MD<sup>5</sup>;

Ellen J. MacKenzie, PhD<sup>4</sup>; for the LEAP (Lower Extremity Assessment Project) Study Group;

<sup>1</sup>William Beaumont Army Medical Center, El Paso, Texas, USA;

<sup>2</sup>Brooke Army Medical Center, San Antonio, Texas, USA;

<sup>3</sup>Orthopaedic Associates of Michigan, Michigan State University, Grand Rapids, Michigan, USA;

<sup>4</sup>Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA;

<sup>5</sup>Carolinas Medical Center, Charlotte, North Carolina, USA

**Purpose/Hypotheses:** There is great clinical interest in identifying the type and extent of soft-tissue injuries that limit the ability to reconstruct injured limbs. Detailed soft-tissue injury data from a large prospective study of limb-threatening injuries may be used to identify the muscles, vessels, and nerves that contribute the most toward predicting amputation. The information gained may allow surgeons to better counsel patients and set their expectations after the initial débridement and to identify areas for future surgical research.

**Methods:** This was a secondary analysis of data from 347 patients with unilateral grade III tibia fractures from a prospective observational study at 8 Level I trauma centers. Of these, 265 patients were treated via salvage and 82 via amputation. Soft-tissue injuries for each of the 4 compartments in the tibia were classified by listing the contents of each compartment (11 muscles, 3 nerves, and 5 vessels) and grading them as 1 (no injury), 2 (impaired), or 3 (nonfunctional or absent). The main outcome measure for this analysis was amputation during the initial hospitalization. Separate hierarchical stepwise logistic regression modeling techniques were used to identify significant predictors of amputation. Results are reported as odds ratios (OR) with 95% confidence intervals (CI). In this abstract, we report all items with ORs indicative of a 300% or greater increase in the risk of amputation.

**Results:** Detailed soft-tissue injury data were strongly predictive of amputation. All 19 items were able to predict amputation with an area under the curve (AUC) of 0.833 (roughly equivalent to 80% sensitivity and specificity). Two components, the posterior tibial artery and the tibial nerve, were so highly correlated that it would have been impossible to include them as separate items in any model, and were merged for this analysis. Using logistic regression we identified a subset of six items (see table), which accounted for 98% of the predictive power of the larger model (AUC = 0.815).

Soft-Tissue Component	OR (95% CI)	P Value
Flexor hallucis longus	4.13 (0.56, 30.3)	0.160
Peroneal artery/vein	6.45 (1.41, 29.5)	0.016
Posterior tibial artery or tibial nerve	9.49 (3.03, 29.7)	<0.001
Superficial peroneal nerve	3.38 (0.92, 12.4)	0.066
Gastrocnemius (lateral head)	7.75 (1.00, 60.1)	0.050

See pages 97 - 144 for financial disclosure information.



**Conclusion:** In a detailed analysis of the individual structures involved in a mangled lower extremity, specific muscle, vascular, and nerve injuries are strong predictors of amputation. Specifically, injury to the flexor hallucis longus and gastrocnemius (lateral head) muscles, the peroneal artery/vein, the posterior tibial artery, and the tibial and superficial peroneal nerves substantially increased the chances of amputation. It is also notable the extent to which these six components accounted for the predictive power of the complete detailed dataset. These results may allow surgeons to more accurately counsel their patients on what to expect and enable them to maximize the predicted functional outcome for a patient with a mangled lower extremity.

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## Predictive Radiographic Markers for Concomitant Ipsilateral Ankle Injuries in Tibial Shaft Fractures

*Patrick Schottel, MD; Marschall B. Berkes, MD; Milton Thomas Michael Little, MD; Lionel Enrique Lazaro, MD; David L. Helfet, MD; Dean G. Lorich, MD; Hospital for Special Surgery, New York, New York, USA*

**Purpose:** Recent publications have identified a tibial shaft fracture variant that contains an ipsilateral posterior malleolus fracture (PMF). As PMFs typically represent only one component of a rotational ankle injury, we hypothesized that tibia fractures with a concomitant rotational ankle injury are underappreciated. We also hypothesized that characteristic tibia and fibula fracture patterns are predictive of a rotational ankle injury. The purpose of this study was to quantify the incidence as well as identify the fracture patterns that are predictive of a concomitant ipsilateral ankle injury.

**Methods:** Preoperative full-length tibia and ankle radiographs as well as a CT scan of the tibia that included the ankle were obtained on all operative tibial shaft fractures from 2009 to 2011. 71 patients were retrospectively reviewed with the location, pattern, and AO classification recorded. Radiographic and CT imaging was then scrutinized for evidence of an ipsilateral rotational ankle injury as judged by the presence of a PMF, an anterior inferior tibiofibular ligament (AITFL) avulsion fracture, or a medial malleolus fracture. The Fisher exact test was used to determine significant associations between fracture patterns and the presence of a rotational ankle injury.

**Results:** 35 (49.3%) of the 71 tibial shaft fracture patients were found to have a concomitant ipsilateral ankle injury. Of those, isolated PMFs occurred in 48.6% (17 of 35), isolated AITFL avulsion fractures occurred in 8.6% (3 of 35) and the remainder of patients possessed two or more ankle injury markers (PMFs, medial malleolus fractures, AITFL avulsion fractures, and a deltoid ligament tear). 31 of 35 (88.6%) concomitant ankle injuries occurred in patients with a spiral pattern type tibia fracture of the distal third diaphysis or metadiaphysis ( $P < 0.001$ ). Identification of a distal third spiral tibia fracture on initial radiographs resulted in an odds ratio (OR) of 13.71 (95% confidence interval [CI], 3.50-58.76) for the presence of an ankle injury compared with all other nonspiral patterns (transverse, oblique, segmental, and butterfly). Distal third spiral tibia fractures had a diagnostic sensitivity of 88.6%, specificity of 63.9%, and positive and negative predictive values of 70.5% and 85.2%, respectively, for the presence of an ankle injury. Also, patients with either a transverse pattern or absent fibula fracture were significantly less likely to have an associated ankle injury (OR 0.04; 95% CI, 0.002-0.731;  $P = 0.016$ ).

**Conclusions:** Ipsilateral ankle injuries including PMFs, AITFL avulsion fractures, and medial malleolar fractures are commonly associated with tibial shaft fractures, specifically distal third spiral type. Recognition of these associated ankle injuries is important as it may impact intraoperative and postoperative management. Further studies examining the outcomes of patients with or without ipsilateral ankle injury is warranted to determine the clinical significance of this entity.

### Results of Complex Proximal Femur Fractures Treated With Locking Proximal Femur Plates

**Cory A. Collinge, MD<sup>1</sup>**; Timothy Weber, MD<sup>2</sup>; J. Tracy Watson, MD<sup>3</sup>; Michael Archdeacon, MD<sup>4</sup>; David Lowenberg, MD<sup>5</sup>; David Zamarano, MD<sup>6</sup>; Florian Huber, MD<sup>7</sup>; Michael Prayson, MD<sup>8</sup>; Timothy Achor, MD<sup>9</sup>;

<sup>1</sup>Harris Methodist Fort Worth Hospital, Fort Worth, Texas, USA;

<sup>2</sup>OrthoIndy, Indianapolis, Indiana, USA;

<sup>3</sup>Saint Louis University School of Medicine, Saint Louis, Missouri, USA;

<sup>4</sup>University of Cincinnati Academic Medical Center, Cincinnati, Ohio, USA;

<sup>5</sup>Stanford University Medical Center, Palo Alto, California, USA;

<sup>6</sup>University of California, Irvine Medical Center, Anaheim, California, USA;

<sup>7</sup>Peninsula Orthopedic Associates, Salisbury, Maryland, USA;

<sup>8</sup>Miami Valley Hospital, Dayton, Ohio, USA;

<sup>9</sup>University of Texas, Houston Medical Center, Houston, Texas, USA

**Background/Purpose:** Complex fractures of the proximal femur involving the peritrochanteric and subtrochanteric areas are a treatment challenge. Intramedullary rods and angled blade plates have been used for these fractures, but specific problems exist with each of these options. As a result, locking proximal femur plates (LPFPs) are now available as a plating option for these fractures to address some of these shortcomings. Clinical evaluation of these plates is not adequately reported. Our purpose was to determine the clinical results of a large series of patients with complex proximal femur fractures treated with an LPFP.

**Methods:** 103 patients with an unstable peri- or subtrochanteric femur fracture were treated with an LPFP between January 2007 and December 2010 at 9 regional trauma centers (7 Level I and 2 Level II). Retrospective analysis of medical record and radiographs was performed of patients with follow-up >12 months. Primary outcomes assessed were union, alignment, fixation failure, need for secondary surgeries, and infection.

**Results:** 65 patients met criteria for inclusion and followed up at an average of 33 months (range, 12-56 months). Treatment failure occurred in 17 patients (26%), including 15 failures of fixation associated with nonunion, malalignment, or malunion requiring revision. Loss of proximal fixation with broken, loosened, or bent implants and resultant varus malalignment was the characteristic mode of failure. There were two deep infections, both requiring plate removal and ultimately total hip arthroplasty. Factors that significantly affected failure included age, tobacco usage, plate manufacturer, and surgical varus malalignment.

**Conclusion:** LPFPs are associated with a relatively high treatment failure rate in the treatment of complex proximal femur fractures. Predictors of failure were identified including increased age, tobacco use, PFLPs from a specific manufacturer, and iatrogenic varus malalignment. The treating surgeon must be aware of a high potential for complication when applying these plates to complex proximal femur fractures.

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**Distal Femoral Anterior Cortical Penetration After Intramedullary Hip Nailing:  
Fact or Fiction?**

*Dan Bazylewicz, MD<sup>1</sup>; Kenneth A. Egol, MD<sup>1</sup>; Kenneth J. Koval, MD<sup>2</sup>;*

*<sup>1</sup>NYU/Hospital for Joint Diseases, New York, New York, USA;*

*<sup>2</sup>Orlando Regional Medical Center, Orlando, Florida, USA*

**Background/Purpose:** There has been concern over distal femoral cortical abutment and penetration after intramedullary (IM) hip nailing because of the known mismatch between the anatomic femoral bow and the bow of currently used IM nails. This mismatch has resulted in IM hip nail redesign, despite a lack of any clinical series reporting the rate or scope of the problem with modern IM hip nail designs. This study was performed to determine the rate of anterior cortical abutment and penetration after nailing of proximal femur fractures in a consecutive series of patients using a nail with a radius of curvature (ROC) of 180 cm, and to determine final nail positions.

**Methods:** Between June 2005 and September 2008, all proximal femoral fractures or impending fractures stabilized at one institution using the Pertrochanteric Nail (PTN, Biomet) were retrospectively evaluated. Fractures were excluded only if the intraoperative or first post-operative lateral radiograph did not include an adequate lateral radiograph demonstrating overlap of the two condyles. The lateral radiographs were reviewed by a single reviewer for presence of cortical abutment and penetration as well as location within the medullary canal from anterior to posterior. Cortical penetration was defined as cortical fracture with nail location beyond the anterior distal femoral cortex. Cortical abutment was defined as nail location within 3 mm of the distal femoral anterior cortex. The space available for the nail at the superior edge of the patella was divided into four equal segments and the proportion of nails lying in each quarter of the possible space available for the nail was determined using the labels "far anterior," "anterior," "posterior," and "far posterior." Statistical analysis was performed ( $\chi^2$  test, comparison of proportions, MedCalc Software) to determine whether there was any relationship between fracture type (31A, 32, pathologic) and nail location in the sagittal plane.

**Results:** 271 fractures were stabilized using the PTN during the time frame. 57 fractures were excluded due to inadequate imaging, leaving 214 nails in 212 patients available for analysis. 144 fractures were in women and 70 were in men. The average patient age was 74 years (range, 18-96). Four nails were used to stabilize pathologic fractures, 22 nails for impending pathologic fractures, 128 nails for an acute pertrochanteric fractures (52 OTA Type 31A1, 62 Type 31A2, 14 Type 31A3), and 60 nails to stabilize subtrochanteric fractures (OTA Type 32). Of the 214 cases available for analysis, there was 1 case (0.47%) of anterior femoral cortical penetration. Of the remaining 213 nails, 35 (16.4%) were within 3 cm of the anterior femoral cortex. Analyzed by quartiles in the suprapatellar region, 40% of nails ended up far anterior, 48% anterior, 10% posterior, and 2% far posterior. No relationship was found between fracture type and rate of penetration or cortical abutment, but nails in pertrochanteric fractures (OTA 31) were more likely to end up in the "far anterior" quarter of the available canal space compared to subtrochanteric fractures (OTA 32) ( $P = 0.02$ ).

**Conclusions:** We found a low rate (0.47%) of distal femoral cortical penetration using an IM hip nail with a radius of curvature of 180 cm. However, the high rate of nail abutment within 3 mm of the anterior cortex (16.4%) remains a concern. 88% of nails ended in the anterior half of the distal femur, which is consistent with a mismatch between the bows of the anatomic femur and IM nail.

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**Early Intervention for Better Survival Rate After Hip Fracture**

*Ely L. Steinberg, MD; Amir Sternheim, MD; Assaf Kadar, MD; Ahuva Melik, MD; Moshe Salai, MD; Ofir Chechik, MD; Orthopaedic Department, Souraky Tel-Aviv Medical Center, Tel-Aviv University, Tel-Aviv, Israel*

**Background/Purpose:** Early operative treatment has been advocated for femoral neck fracture fixation. In the present study we retrospectively assessed files of patients operated on in our hospital and tried to evaluate patients' survival in correlation with time to surgery.

**Methods:** Data of 1940 patients operated for fracture of the femoral neck between January 2008 and June 2011 were assessed. All patients were assessed for American Society of Anesthesiologists (ASA) and Charlson scores as well as demographic parameters. Patients treated either by hemiarthroplasty, dynamic compression plate, or hip nail were included in the study. There were 1308 females and 632 males with an average age of 77.6 years (range, 17-107). 1248 patients (64%) were treated within 48 hours and 692 (36%) were treated after 48 hours. Survival was assessed using the data received from the national inhabitant registry.

**Results:** 1-year survival rate for patients with a poor Charlson score was 71%; for moderate, 87%; and for mild, 98%. According to the ASA score, the survival rate for scores 1 or 2 was equal (96%), decreased to 79% for score 3, and further lower for score 4 (64%). Comparing two groups of patients treated within 48 hours and after 48 hours, the survival rates for the first 60 postoperative days were 96% and 93%, respectively, with a hazard ratio of 1.31 for the group operated after 48 hours versus within 48 hours, adjusted for Charlson score for age and sex. Comparing the two groups, the survival rates for 1 year postoperatively were 90% and 81%, respectively, with a hazard ratio of 1.5 for the group operated after 48 hours versus within 48 hours, adjusted for Charlson score for age and sex. Males had an increased hazard ratio at 60 days and at 1 year for age and ASA score.

**Conclusions:** Early surgery is most important for mobility and preventing early postfracture complications. In the present study we found that early operation within 48 hours increases the survival rate and decreases mortality hazard ratio postoperatively. These results are comparable and even better compared with other published data and we strongly encourage adhering to these recommendations.

### **The Effects of “Old” Red Blood Cell Transfusion on Mortality and Morbidity in Elderly Patients With Hip Fractures**

*Assaf Kadar, MD; Ofir Chechik, MD; Gabby Meghiddo, MD; Amir Sternheim, MD; Department of Orthopedics, Tel Aviv Sourasky Medical Center, Sackler Faculty of Medicine, Tel Aviv University, Ramat Aviv, Israel*

**Background/Purpose:** Elderly patients admitted with hip fractures often receive allogenic blood transfusion (ABT) in the perioperative period. ABTs with a longer storage time have been shown to have a negative impact on mortality in patients undergoing cardiac surgery. We examined the effect of the number and age of transfused allograft red blood cells on mortality and morbidity.

**Methods:** 1381 elderly patients with hip fractures were retrospectively analyzed. The cutoff between “new” and “old” ABT was defined as 14 days from donation (new, 1-14 days; old, 14-30 days). Kaplan-Meier curves were used to assess survival. Log-rank test was used to examine the differences between the five groups (no ABTs, one new ABT, one old ABT, two new ABTs, and two old ABTs). A sub-group analysis comparing 2 old ABTs (95 patients) versus 2 new ABTs (138 patients) with regard to cardiac, pulmonary, thromboembolic, and infective complications was also conducted.

**Results:** Kaplan-Meier survival curves differed significantly ( $P = 0.008$ ) between the five groups of patients. Patients who did not receive ABT (718 patients) showed the best survival. In descending order of survival, patients who received one new ABT (243 patients), one old ABT (187 patients), two new ABTs (138 patients), and two old ABTs (95 patients) fared worse. When controlling for age and gender, this trend of survival was still evident but not significant. On subgroup analysis of two old versus two new ABTs, there were no differences in postoperative complications.

**Conclusion:** Patients undergoing surgery for hip fractures who received more units of old ABT had a significantly decreased survival rate compared to those who received new ABTs and fewer transfusions.

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**The Incidence of Femoral Neck Fractures Associated With Floating Knee Injuries**

Bret D. Beavers, MD<sup>1</sup>; Robert N. Reddix, Jr., MD<sup>1,2</sup>; Terry E. Rives, PhD, MPH<sup>1</sup>;

<sup>1</sup>John Peter Smith Hospital Orthopaedic Surgery Residency Program, Fort Worth, Texas, USA;

<sup>2</sup>University of North Texas Health Science Center, Fort Worth, Texas, USA;

**Purpose:** Our hypothesis was that patients with ipsilateral femoral shaft and tibia plateau/shaft fractures (floating knees) would have an increased incidence of femoral neck fractures, higher ISS, and longer hospital stays.

**Methods:** Utilizing our institution's trauma registry, we identified patients from April 2002 to September 2010 with femoral shaft fractures. We retrospectively reviewed these patients' medical records to identify mechanism of injury, Gustilo-Anderson grade for open injuries, fracture type and location, associated injuries, presence of a femoral neck fracture, fixation method, length of hospital stay, and the presence or absence of an ipsilateral tibia fracture.

**Results:** Our study group consisted of 458 femoral shaft fractures in 428 patients with an average age of 30 years (range, 13-89). Of these 458 femoral shaft fractures, we identified 66 patients with 71 extremities that had a fracture of the ipsilateral tibial plateau or shaft (group 1). Our internal control group, group 2, consisted of 387 isolated femoral shaft in 373 patients. There were 8 of 66 (12%) deaths in group 1 versus 9 of 373 (2.7%) in group 2. Femur fractures were treated with a retrograde approach in 68% of extremities in group 1 versus 46% in group 2. Femoral neck fractures were identified in 11 of 71 extremities (15.5%) in group 1 versus 27 of 387 extremities (7%) in group 2. There was a statistically significant difference between the two groups when comparing the incidence of femoral neck fractures. There was also a significant difference in ISS (26 vs 16) and hospital stays (21 vs 10 days) between the two groups.

**Conclusion:** We found an increased incidence of femoral neck fractures in floating knee injuries, as well as higher ISS and longer hospital stay. This highlights the high-energy nature of patients with this injury constellation.



**Intramedullary Nailing of Subtrochanteric Fractures: Does Malreduction Matter?**

*John Riehl, MD; George J. Haidukewych, MD; Mark W. Munro, MD;  
Joshua Langford, MD; Stanley Kupiszewski, MD; Kenneth J. Koval, MD;  
Orlando Regional Medical Center, Orlando, Florida, USA*

**Background/Purpose:** Subtrochanteric femur fractures remain challenging injuries to treat. Historically, varus malreduction has been linked to the development of nonunion; however, there is a paucity of literature evaluating the impact of sagittal plane malreduction. The purpose of this study was to evaluate the influence of coronal and sagittal plane malreductions on time to union of subtrochanteric femur fractures treated with an intramedullary device.

**Methods:** A retrospective study was performed of all subtrochanteric fractures (AO/OTA type 32) treated at our institution between March 2008 and February 2011. Inclusion criteria included: (1) age  $\geq 18$  years old, (2) fracture stabilization using an intramedullary device, and (3) minimum 3-month follow-up. Patients were followed to union or revision surgery. Radiographic evidence of healing was defined as bridging callus on 3 of 4 cortices on AP and lateral views. Delayed union was defined as lack of radiographic healing by 4 months postoperatively and nonunion as lack of healing by 6 months. The definition of malreduction was coronal or sagittal plane deformity greater than  $10^\circ$  at the fracture site.

**Results:** 35 patients (35 fractures) met inclusion criteria—20 men and 15 women with an average age of 55 years (range, 19-100). Mean clinical follow-up was 7 months (range, 3-18). 34 of 35 fractures (97%) healed without need for additional surgery. 21 of the 35 fractures (60%) healed within 4 months of surgery. 13 fractures (37%) had delayed union and 1 (2.9%) developed nonunion requiring reoperation. 7 of 35 fractures (20%) had a malreduction  $>10^\circ$ , defined as varus (2 fractures), flexion (4 fractures), or both (1 fracture). Of the 7 fractures with a malreduction, all (100%) developed a delayed union (6) or nonunion (1). Of the 28 fractures without malreduction, 21 (75%) healed within 4 months, 7 (25%) had a delayed union, and none had a nonunion. The presence of a malreduction  $>10^\circ$  in any plane resulted in a significantly higher rate of delayed or nonunion ( $P = 0.0005$ ).

**Conclusion:** For patients with subtrochanteric fractures treated with an intramedullary device, malreduction in any plane of greater than  $10^\circ$  resulted in a significantly increased rate of delayed union and/or nonunion.

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**New Oral Antithrombotic for Hip Fracture: A Standardized Protocol**

Daniel Godoy, MD<sup>1</sup>; Alberto Cid Casteulani<sup>2</sup>; Kenneth Iserson, MD<sup>3</sup>; Santiago Svarzchtein, MD<sup>2</sup>; Eliseo Firman, MD<sup>2</sup>; Sebastian Sasaki, MD<sup>2</sup>; Diego Roncolato, MD<sup>2</sup>;

<sup>1</sup>Hospital Italiano de Buenos Aires, Buenos Aires Argentina;

<sup>2</sup>Centro Medico Integral Fitz Roy, Buenos Aires, Argentina;

<sup>3</sup>University of Arizona, Tucson, Arizona, USA

**Background/Purpose:** Patients with hip fracture have a reported incidence of deep vein thrombosis (DVT) between 25% and 63%. A new oral antithrombotic (oral, single dose, no laboratory test) offers a way to reduce this incidence. A new drug has been approved for this use in Argentina. In 2009, we started a protocol for DVT prophylaxis: (A) administration of rivaroxaban (Xarelto, Bayer) 10 mg orally once a day within 24 hours of injury; (B) Doppler scan examination on both limbs immediately after surgery and 30 days after surgery; (C) ventilation perfusion scintigraphy (V/Q scan) if the patient showed clinical signs of pulmonary embolism (PE); (D) clinical evaluation at 45, 90, and 120 days.

**Methods:** From June 2009 to June 2011, we treated 145 consecutive patients with 147 proximal femur fractures (2 bilateral). Associated injuries were found in 27 patients. ISS in this group ranged from 1 to 75 (mean, 9). There were 47 total hip replacements (23 uncemented, 21 hybrid, and 3 cemented); 51 endomedullary systems, and 49 dynamic hip screws. 135 had epidural anesthesia and 10 required general anesthesia. Time to surgery ranged from 1 to 6 days (average, 1.8 days). The patient ages were 18 to 73 years (average, 57.3 years), with 86 male (59.3%), and 59 female (40.7%).

**Results:** No patient had a detected DVT after postoperative Doppler scan. During the 30-day follow-up, 1 had a PE (V/Q scan positive, Doppler scan negative) and 11 had DVTs (3 proximal and 8 distal). The 3 symptomatic patients included 2 with distal DVT who developed symptoms during in-hospital rehabilitation and 1 with a proximal DVT who was readmitted. Both started low molecular-weight heparin treatment per our hospital guidelines. The incidence of PE in the series was 0.68%, Doppler scan-detected DVT 7.5% (2% symptomatic DVT). No patient died during the study follow-up. There was no increase in bleeding, wound oozing, or extra transfusions. Complications included 1 hematoma involving two-thirds of the thigh, 1 wound infection requiring surgical toilet, and 2 patients with rash that resolved after discontinuation of the antithrombotic drug. During clinical evaluation at 45, 90, and 120 days, no clinical complications related to the use of this protocol were detected.

**Conclusion:** Rivaroxaban is a safe and effective method of thromboprophylaxis in patients with hip fractures with or without associated injuries.

### Proximal Femoral Replacement in the Management of Acute Periprosthetic Fractures of the Hip: A Competing Risks Survival Analysis

Matthew Colman, MD<sup>1</sup>; Lisa Choi, MD<sup>1</sup>; Antonia Chen, MD<sup>1</sup>; Dan Winger, MS<sup>2</sup>;

<sup>\*</sup>Peter Siska, MD<sup>1</sup>; Mark Goodman, MD<sup>1</sup>; Lawrence Crossett, MD<sup>1</sup>; Ivan S. Tarkin, MD<sup>1</sup>;

Richard McGough, MD<sup>1</sup>;

<sup>1</sup>Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, Pennsylvania, USA;

<sup>2</sup>Clinical and Translational Science Institute (CTSI), University of Pittsburgh, Pittsburgh, Pennsylvania, USA

**Background/Purpose:** With advancing osteopenia, lytic defects, and a history of revision, hip arthroplasty patients are exposed to massive failure of implants at the time of periprosthetic fracture. This study examines the outcomes of proximal femoral replacement (PFR) as compared to revision total hip arthroplasty (REV) or open reduction and internal fixation (ORIF) in these non-oncologic hosts.

**Methods:** 101 consecutive periprosthetic hip fractures were treated at our center with average 35-month follow-up. Three treatment groups were identified: PFR (n = 23), REV (n = 20), and ORIF (n = 58). We recorded comorbidities, fracture type, treatment profiles, complications, and mortality. The three groups were compared using competing risks survival analysis, a Kaplan-Meier-like estimate that takes into account multiple competing outcomes.

**Results:** The PFR group was similar to the REV and ORIF groups in all respects except for its higher incidence of pulmonary disease and Vancouver B3 fractures. Competing risk survival analysis using a Gray comparison of overall mortality during the mean 35-month follow-up showed no difference between the three groups ( $P = 0.65$ ; 12 and 60-month mortality for PFR: 37%, 45%; REV: 16%, 46%; ORIF: 14%, 100%). However, implant survival was worse for the PFR group ( $P = 0.03$ ; 12 and 60-month implant survival rate for PFR: 95%, 61%; REV: 93%, 93%; ORIF 98%, 98%). There was no difference between groups with regard to summary nondeath complications including deep vein thrombosis, infection, dislocation, and other measures (30% vs 40% vs 34%,  $P = 0.80$ ). Comparing only the PFR group to the REV group, PFR had a trend toward higher dislocation (26% vs 5%,  $P = 0.062$ ), although infection rates (17% vs 15%,  $P = 0.83$ ) were not different. Operative times were not different between the three groups (172 min vs 162 min vs 168 min,  $P = 0.92$ ).

**Conclusions:** In treating difficult periprosthetic fractures, PFR as compared with REV or ORIF has worse medium-term implant survival, similar perioperative complication rates, similar short and long-term mortality, and similar operative times. Caution should be used when considering the use of this implant in nononcologic hosts with long-term life expectancy.

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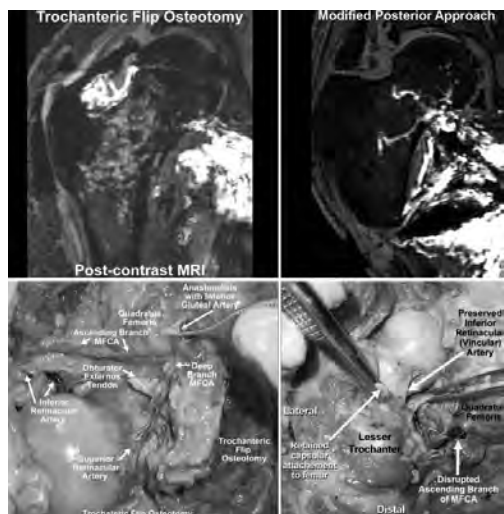
**Assessment of Perfusion to the Femoral Head and Head-Neck Junction Following Surgical Hip Dislocation Using Gadolinium-Enhanced Magnetic Resonance Imaging***Lionel E. Lazaro, MD<sup>1</sup>; David S. Wellman, MD<sup>1</sup>; Peter K. Sculco, MD<sup>1</sup>;**Craig E. Klinger, BS<sup>1</sup>; Jonathan P. Dyke, PhD<sup>2</sup>; Nadine C. Pardee, BS<sup>1</sup>; Edwin P. Su, MD<sup>1</sup>;**David L. Helfet, MD<sup>1</sup>; Dean G. Lorich, MD<sup>1</sup>;**<sup>1</sup>Hospital for Special Surgery and Weill Medical College of Cornell University, New York, New York, USA;**<sup>2</sup>Citigroup Biomedical Imaging Center, Weill Medical College of Cornell University, New York, New York, USA*

**Background/Purpose:** Osteonecrosis (ON) of the femoral head (FH) is a significant complication that can arise following surgical hip dislocation. Wide exposure and direct approach to the FH and acetabulum is essential for the treatment of severe hip disease and hip trauma in both the pediatric and adult populations. Ganz et al developed an anterior surgical hip dislocation through a posterior approach using a “trochanteric flip” osteotomy (TFO, upper and lower left figures), which provides excellent exposure while preserving the FH blood supply, as evidenced by intraoperative laser Doppler and the absence of ON on follow-up radiographs. Due to personal preference and comfort, many arthroplasty surgeons continue to use the posterior dislocation approach for resurfacing procedures. During take-down of the external rotator, this approach disrupts the deep and/or ascending branch of medial femoral circumflex artery (MFCA) and the anastomosis with the inferior gluteal artery, compromising the blood supply to the FH. Recently, Steffen et al recommended a “modified blood-preserving posterior approach” (MPA, upper and lower right figures) for hip resurfacing, which employs a capsulotomy at the margin of the acetabulum and was reported to maintain intraoperative FH oxygenation. This study seeks to evaluate and quantify perfusion to the FH and head-neck junction (HNJ) using gadolinium-enhanced MRI following both surgical hip dislocations (TFO and MPA), which has not been previously reported.

**Methods:** In 40 fresh-frozen cadaveric hips (20 pelvic specimens), we cannulated the MFCA. One hip on each pelvic specimen was randomly chosen to undergo one of two surgical hip dislocations (MPA or TFO), and the contralateral hip was used as a control. Gadolinium was injected through the cannulated MFCA, and pre- and postcontrast MRI was performed. Gadolinium enhancement on the MRI was quantified in both the FH and HNJ for volumetric analysis using custom MRI analysis software. Urethane compound was then injected and gross dissection was performed to assess the extraosseous vasculature of the FH.

**Results:** MRI quantification revealed that the TFO group maintained almost full perfusion to the HNJ (98%) and FH (96%). The MPA resulted in a larger reduction of FH and HNJ perfusion with an average perfusion of 48% and 45%, respectively. Gross dissection revealed that 7 of 10 specimens in the MPA group sustained complete disruption of the ascending branch of the MFCA, and no urethane was found in the superior retinacular arterial system. The inferior retinacular artery (vincular artery) was found to be intact with urethane perfusion in 9 of 10 MPA specimens and all the TFO specimens. All specimens in the TFO group had both vessel systems intact, including the superior and inferior retinacular arteries.

**Conclusion:** This study confirms that the anterior surgical hip dislocation through a TFO preserves the vascular supply to the FH and HNJ, while the MPA results in a marked reduction of the FH and HNJ perfusion, likely secondary to transection of the ascending branch of the MFCA. Despite reduced enhancement, significant perfusion of the FH and HNJ was present in the MPA group, likely due to preservation of the inferior retinacular artery when a careful capsulotomy is performed. Our study provides previously unreported MRI quantitative data on the perfusion to the FH and HNJ following extremely common surgical hip dislocation techniques (TFO, MPA).



POSTER ABSTRACTS

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### **Aseptic Diaphyseal Femoral Nonunions: Exchange Intramedullary Nailing Versus Dynamization**

*Jeffrey P. Garrett, MD; Rafael Serrano-Riera, MD; H. Claude Sagi, MD;  
Orthopaedic Trauma Service, Florida Orthopaedic Institute, Tampa, Florida, USA*

**Purpose:** Intramedullary nailing is the gold standard treatment for fractures of the femoral diaphysis. For those fractures in which nonunion occurs, different treatment strategies are available. The purpose of this study is to compare the union rates of aseptic femoral diaphyseal nonunions using intramedullary nail dynamization and those using exchange intramedullary nailing with and without bone graft.

**Methods:** Between 2002 and 2010, 1099 femoral shaft fractures were treated with an intramedullary nail. 46 patients with aseptic femoral diaphyseal nonunions without segmental defect and either a spiral (32 A1.2), oblique (32 A2.2), or transverse (32 A3.2) fracture line were identified in 42 patients and included in the study. All patients were initially treated with intramedullary nailing and subsequently had radiographic and clinical findings of symptomatic nonunion. Time to treatment until diagnosis of nonunion averaged 11 months (range, 3-30 months). Patients were excluded if they were skeletally immature or had a history of bone infection, tumor, or metabolic disorder. The study population was divided into three groups for analysis: group one, nail dynamization (ND) only; group two, exchange intramedullary nailing (XIM) only; and group three, exchange intramedullary nailing with open bone grafting (XIMG) of the nonunion site. Clinical data were analyzed using Fisher exact test.

**Results:** There were 11 patients in group one, 20 patients in group two, and 22 patients in group three. Age, gender, and fracture patterns did not differ significantly between the three groups. Success rates were as follows: group one (ND), 2 of 11 (18%) nonunions healed; group two (XIM), 14 of 20 (70%) nonunions healed; group three (XIMG), 20 of 22 (93%) nonunions healed. The differences between group one and groups two and three were statistically significant ( $P = 0.003$ ).

**Conclusions:** We found exchange intramedullary nailing to be significantly more effective than dynamization in the treatment of aseptic femoral diaphyseal nonunions. Union was also improved with the addition of bone autograft at the time of exchange although this was not statistically significant.

## Is Operative Delay in Hip Fracture Patients on Clopidogrel (Plavix) Warranted? A Comorbidity Matched Analysis

*Chris Casstevens, MD; J. Patrick Martens; Michael T. Archdeacon, MD;  
B. J. Johnson; Theodore Toan Le, MD; John D. Wyrick;  
Department of Orthopaedic Surgery, University of Cincinnati Medical Center,  
Cincinnati, Ohio, USA*

**Purpose:** There is a paucity of literature that addresses potential delays in operative treatment for hip fracture patients who present with inhibited platelet function secondary to antiplatelet medications. The purpose of this study was to compare the occurrence and magnitude of operative delay, surgical blood loss, and 1-year mortality for hip fracture patients on clopidogrel to a comorbidity-matched cohort not on clopidogrel.

**Methods:** We queried our billing database for hip fracture patients treated operatively over a 9-year period. We identified patients who presented on clopidogrel (Group P) and calculated the Charlson Comorbidity Index for this group. A matched control group of patients not on clopidogrel preoperatively was selected with matching age-adjusted Charlson scores (Group N). The groups were compared using standard *t* tests, Wilcoxon rank-sum tests,  $\chi^2$  tests, or a two-tailed Fisher exact test. For mortality, a McNemar test for discordant pairs was used to analyze the data in a matched fashion.

**Results:** We identified 27 (4.8%) of 557 patients with a mean age of  $79.1 \pm 10.1$  years who were taking clopidogrel at presentation with a hip fracture (Group P). The control group used for comparison consisted of 27 patients drawn from the same search matched with the same age-adjusted Charlson score (Group N). Median operative delay was 4 days in Group P and 1 day in Group N ( $P < 0.01$ ). Median estimated operative blood loss was 200 mL in both groups ( $P = 0.99$ ). One-year mortality was 30% (8 of 27) in both groups ( $P = 1.0$ ) with no significant difference noted using the McNemar test ( $P = 1.0$ ).

**Conclusions:** Our data demonstrated an increase in operative delay among patients on clopidogrel; however, the effects of clopidogrel on platelet function did not appear to have an adverse effect on hemostasis in these hip fracture patients. The morbidity and mortality in hip fracture patients on clopidogrel at admission were nearly identical to those seen in patients with comparable levels of medical comorbidities not taking clopidogrel.

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**Surgical Time of Day Does Not Affect Outcome Following Hip Fracture Fixation***Ryan E. Bennett, MD; Andrea J. Vlasak, MD; Steve R. Gammon, MD;**Sandy Vang, BS; Julie A. Switzer, MD;**University of Minnesota/Regions Hospital, Minneapolis-St. Paul, Minnesota, USA*

**Background/Purpose:** Approximately 300,000 hip fractures occur yearly within the United States. This number is projected to double by 2050. Mortality rates for all patients with hip fractures approach 30%, and perioperative complications are common. In spite of the high complication rate associated with hip fractures in the elderly population, surgical repair of these fractures is often undertaken at night. Multiple studies in the general medical literature have found that work done at night is more likely to result in complications. There is, however, little evidence regarding the effect of the time of day on the outcome of surgical repair of hip fractures. We present a retrospective study comparing the outcomes of surgery for hip fractures based on the time of day of surgery. Our hypothesis was that hip fracture patients who have surgery in the evening or night have worse outcomes than those who have surgery during the day.

**Methods:** A retrospective study of was performed on 1552 consecutive patients with a diagnosis of intertrochanteric, subtrochanteric, or femoral neck fracture from 2005 to 2010 at a single Level I trauma center. 860 patients met the inclusion criteria (age  $\geq 50$  years, isolated injury, and surgical treatment of the fracture). Surgeries were grouped by time of surgical incision into an AM group (07:00-15:59) and a PM group (16:00-06:59). Medical records were analyzed for age, comorbidities, American Society of Anesthesiologists (ASA) class, 30-day mortality, readmission, reoperation, time to surgery, procedure length, total time in the operating room, intraoperative fracture, and medical complications (myocardial infarction, cardiac event, stroke, central nervous system event, pneumonia, urinary tract infection, postoperative wound infection, bleeding requiring transfusion of three or more red blood cell units).

**Results:** 860 patients met the inclusion criteria. 660 patients underwent surgery in the time period designated as the AM group. 200 patients underwent surgery in the time period designated as the PM group. There was no statistical difference between the groups regarding age, ASA score, Charlson comorbidity index, gender, or fracture type. The overall 30-day mortality was 7.8%. The total complication rate was 28%. There was no significant difference found in either 30-day mortality or total complication rate based on the time of day that the surgery was performed ( $P = 0.88$  and  $P = 0.86$ , respectively). This remained unchanged when ASA class, Charlson comorbidity index, and age were taken into account. A multivariate analysis of the risk factors collected was performed to determine which factors did affect outcomes in our study. Age (odds ratio [OR] = 1.034/year), Charlson score (OR = 1.155), ASA class (OR = 1.405), and total operating room time (OR = 1.688) were all found to predict adverse outcomes. Female gender was found to be protective (OR = 0.679). Type of surgery, fracture site, total surgery time, and surgery time of day did not predict adverse outcomes.

**Conclusion:** In our study population, surgical time of day did not affect the 30-day mortality or number of complications. As the number of hip fractures increases, the demands on



orthopaedic surgeons will increase as well. Surgical treatment within 48 hours has been shown to reduce morbidity and mortality of hip fractures. Our study shows that operating after hours did not increase the risk of adverse events surrounding surgery. Age, ASA class, Charlson comorbidity index, and total time in the operating room were predictive of adverse outcomes. This information may be used to discuss the risks of the surgical repair of hip fractures with patients and their families.

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### Morphology of Displaced Paewels III Vertical Femoral Neck Fractures in Young Adults

Cory A. Collinge, MD<sup>1,2</sup>; Robert N. Reddix, Jr., MD<sup>2</sup>;

<sup>1</sup>Harris Methodist Fort Worth Hospital, Fort Worth, Texas, USA;

<sup>2</sup>John Peter Smith Orthopedic Surgery Residency, Fort Worth, Texas, USA

**Purpose:** Management of vertical femoral neck fractures in young adults has been challenging and resulted in mixed clinical outcomes. Understanding of the fracture morphology for this injury pattern is lacking, which may contribute to frequent failures of treatment. This study is designed to produce a detailed description of the pathoanatomy of this fracture, which may be helpful in forming reduction and fixation strategies for these injuries.

**Methods:** This is a retrospective study of patient records and radiography of patients <60 years of age with a displaced vertical Paewels III femoral neck fracture that was surgically repaired at one of two adjacent regional trauma centers (one Level I, one Level II) from January 2007 to December 2010. Patients with ipsilateral femoral or acetabular fractures were excluded. 22 patients underwent preoperative CT; these data were reviewed in multiple planes and assessed for fracture angle, deformity, comminution, and competence of the calcar's cortical buttress.

**Results:** The average vertical fracture measured 61° (range, 52°-78°) on coronal CT and the average fracture obliquity of the head-neck fragment on axial CT measured 38° (range, 8°-61°) with relative deficiency of the posterior neck in all cases. All patients had external rotation deformity that averaged 44° (range, 10°-68°) and shortening of the femur averaging 2.1 cm (range, 0.9-4.4 cm). Femoral neck comminution >1.5 cm in any dimension was identified in 95% of cases, mostly posteriorly (94%) and inferiorly (94%). A competent calcar cortex estimated to predictably buttress a well-placed inferior lag screw was seen in only 9 of 19 (47%) cases.

**Conclusions:** This study investigated the fracture morphology of Paewels III vertical femoral neck fractures in young adults, which may facilitate improved results of operative reduction and fixation. Given the high frequency of this injury's characteristic findings, including fracture orientation, deformity, and comminution, surgeons should be cognizant of this pattern's innate instability and potential for treatment failure with typical implant constructs.

## Treatment of Femoral Neck Fractures With a Novel Length-Stable Construct Leads to High Union Rates With Minimal Femoral Neck Shortening

Lionel E. Lazaro, MD; Milton T.M. Little, MD; Marschall B. Berkes, MD; Patrick C. Schottle, MD; Nadine C. Pardee, BS; David L. Helfet, MD; Dean G. Lorich, MD; Hospital for Special Surgery and Weill Medical College of Cornell University, New York, New York, USA

**Background/Purpose:** The traditional treatment of femoral neck fractures allows sliding in order to permit dynamic compression at the fracture site, but some shortening of the femoral neck invariably follows. Previous studies have demonstrated the negative impact of femoral neck shortening (FNS), but normal hip biomechanics and function are often sacrificed to maximize the potential for fracture healing. Length-stable fixation (open anatomic reduction, intraoperative compression with partially threaded cancellous screws, and final length-stable fixation with fully threaded screws) seemed to provide a solution, with reports of improved clinical outcomes and decreased FNS. Nevertheless, this fixation technique needed refinement to better avoid FNS. We sought to increase the strength of the construct and host bone interface with a strategically placed fibula allograft (control varus/valgus deformity) as a “biologic screw” (figure). It was our hypothesis that this construct would result in better preservation of intraoperative reduction and improved clinical outcomes compared to historical controls fixed with length stable constructs.

**Methods:** 18 consecutive femoral neck fractures treated with this novel length-stable construct were initially reviewed. 16 met inclusion criteria with a minimum of 6 months’ radiographic and clinical follow-up. All construct failures were included regardless of length of follow-up. Main outcome measurements included radiographic (reduction maintenance, head migration, FNS, and variation of neck offset and abductor lever arm) and functional (Harris hip score [HHS] and Short Form 36 [SF-36]) outcomes.



head migration, FNS, and variation of neck offset and abductor lever arm) and functional (Harris hip score [HHS] and Short Form 36 [SF-36]) outcomes.

**Results:** Average age was 59.4 years (range, 30-78). The average radiographic and clinical follow-up was 12 months (range, 6-24) and 14.5 months (range, 6-26), respectively. Garden classifications of the fractures included 3 GI, 0 GII, 7 GIII, and 6 GIV (one of which was a revision case after a failed sliding construct; figure). Anatomic reduction ( $<5^\circ$  difference in neck-shaft angle,  $<2$  mm step-off) was achieved in all patients. There was one catastrophic failure (varus displacement with proximal migration of the fibula) 2 weeks after fixation that required total hip replacement. This single failure was attributed to a technical error (misplacement of the fibula allograft) during fixation. The remaining 15 patients achieved bony union. The average displacement of the center of



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the head did not differ compared to historical controls using length-stable construct ( $1.65 \pm 4.9$  mm inferiorly,  $0.058 \pm 2.9$ mm medially,  $0.6^\circ$  of increased varus vs historical data of  $0.86$  mm,  $1.23$  mm and  $0.6^\circ$ ). The average femoral neck collapse was lower compared to historical controls ( $0.33 \pm 2.82$  mm vs  $1.98$  mm;  $P = 0.049$ ). Average HHS and SF-36 (mental/physical component) did not differ compared to historical control (87 and 49/46 vs 85 and 47/42). The average difference in femoral neck offset and abductor lever arm length did not differ compared to historical controls ( $0.23 \pm 7.1$ mm and  $-1.26 \pm 6.9$ mm vs  $3.5 \pm 8.3$ mm and  $1.5 \pm 7.8$ mm). No subjects demonstrated osteonecrosis on the most recent radiograph (13 patients with >1-year radiographic follow-up). Three patients had removal of hardware, two with excision of extensive heterotopic ossification (Brooker Grade III). Our radiographic outcomes compare favorably with sliding construct fixation data, recently reported as mean 6.2 mm FNS and 4.8 mm inferior shortening.

**Conclusion:** Intraoperative compression, coupled with this novel length- and angle-stable construct using allograft fibula, can result in high union rates with minimal femoral neck shortening and improved clinical outcomes following femoral neck open reduction and internal fixation.

### **Preoperative Traction in Trochanteric Fractures Treated With a Gamma3 Nail: Determination of the Impact in 347 Cases**

*Rainer H. Burgkart, MD, PhD<sup>1</sup>; Erik Wilde, MD<sup>2</sup>; Andreas Paech, MD<sup>2</sup>; Johannes Kiene<sup>2</sup>; Christian Juergens, MD<sup>2,3</sup>; Arndt P. Schulz, MD, PhD<sup>2,3</sup>;*

*<sup>1</sup>Clinic for Orthopaedics and Traumatology, Technische Universität München, München, Germany;*

*<sup>2</sup>University Hospital SH, Campus Lübeck, Lübeck, Germany;*

*<sup>3</sup>BG Trauma Hospital, Hamburg, Germany*

**Background/Purpose:** Following a hip fracture, traction may be applied to the injured limb before surgery with an aim to reduce pain and facilitate the surgical procedure. There is evidence, however, that the preoperative pain is not positively influenced by this procedure. So far there is no evidence that skin traction facilitates the surgical procedure; on the other hand, it is well recognized that skin traction can be responsible for vascular and neurologic complications as well as infections. The rationale of this study was to evaluate if skin traction has an impact on the postoperative result and complication rate. Patient population in this study is derived from the international prospective Gamma3 follow-up study of Schulz et al. The aim was to evaluate the effects of traction after trochanteric fracture, hypothesizing that there is no measurable effect.

**Methods:** The study design of the Gamma3 study has been described in detail elsewhere. In brief, it is designed as an international prospective clinical follow-up evaluation. The presented data of 347 patients were collected in April 2011. Data are derived from 5 centers. In 56.6% of all cases a preoperative traction had been used. There was no significant difference in terms of subject age ( $P = 0.06$ ). There were more female patients who received preoperative traction than male subjects: 60.3% of all female subjects received this kind of preoperative preparation, while 49.0% of all men received the same treatment; these findings were not significant ( $P = 0.091$ ). There was also no significant difference with respect to body mass index ( $P = 0.114$ ).

**Results:** There was no detectable statistical difference regarding the parameters of pain, device-related complications, medical complications, or mobility at 4 months (all  $P > 0.05$ ). Regarding total surgery time, subjects with preoperative traction had highly significant lower total surgery times ( $P < 0.001$ ); the same applied for the skin-to-skin time ( $P < 0.001$ ). To elucidate this, we stratified results according to the OTA classification and the types of implant (long/short nail). Apart from the subtrochanteric fracture types ( $P = 0.338$ ), results showed significantly shorter procedure times for subjects with preoperative traction (all  $P < 0.05$ ).

**Conclusion:** In our prospective trial we could show that there appears to be no benefit of traction for pain, complications, or outcome. From the evidence available, the routine use of traction prior to surgery for a hip fracture does not appear to have any benefit apart from procedure time.

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### What is the Clinical and Economic Impact of Preoperative Transthoracic Echocardiography on Elderly Patients With Hip Fractures?

*Andrew J. Marcantonio, MD; Brandon M. Steen, MD; Michael S. Kain, MD; Kasey J. Bramlett, PA-C; John F. Tilzey, MD; Richard Iorio, MD; Lahey Clinic Medical Center, Burlington, Massachusetts, USA*

**Purpose:** Elderly patients with hip fractures frequently require preoperative medical consultation. The purpose of this study was to evaluate the effect of preoperative transthoracic echocardiography (TTE) on perioperative cardiac intervention, choice of regional or general anesthesia, timing of hip surgery, length of stay, inpatient mortality, and economic impact.

**Methods:** A retrospective case-controlled series of patients >65 years old who had hip fracture surgery was analyzed. 43 patients who had preoperative TTE were identified. 161 consecutive hip fracture patients who did not undergo TTE were used as a control group for comparison. Data collected included American Society of Anesthesiologists (ASA) score, comorbidities, indication for TTE, time from admission to surgery, need for perioperative cardiac intervention, choice of anesthesia, length of stay, and inpatient mortality. A resource-based hospital accounting system (TSI Inc) provided actual hospital cost data for each procedure.

**Results:** In the TTE group 1 of 43 patients (2.4%) had a cardiac intervention (percutaneous transluminal coronary angioplasty and coronary artery bypass grafting). There were no cardiac interventions in the control group. Average time to operating room was 1.5 days in the TTE group and 0.93 days in the control group ( $P < 0.001$ ). Average length of stay was 7.2 days in the TTE group and 6.0 days in the control group ( $P = 0.04$ ). In patients with a preoperative ASA score of 3 or 4, length of stay in the TTE group was 7.3 days, and 6.3 days in the control group ( $P = 0.18$ ). Inpatient mortality was 2.3% in the TTE group and 3% in the control group ( $P = 0.493$ ). There was no correlation between findings on TTE and choice of anesthesia. A comparison of hospital costs for patients who underwent TTE and the control group demonstrated a significant difference in hospital cost between the groups (TTE \$24,445 vs control \$18,429,  $P = 0.02$ ).

**Conclusions/Significance:** Preoperative TTE in elderly patients with hip fractures resulted in a low cardiac intervention rate. Patients who underwent preoperative TTE prior to hip fracture repair had significantly longer times to operation, longer lengths of stay, and significantly higher hospital costs. The utility of TTE as a preoperative screening tool is limited in the geriatric hip fracture population and does not appear to affect perioperative mortality rates.

### Clinical and Economic Impact of Generic Implant Usage for the Treatment of Femoral Neck Fractures

Justin R. Kauk, MD<sup>1</sup>; Peter L. Althausen, MD<sup>1</sup>, MBA; Daniel J. Coll, MHS, PA-C<sup>2</sup>; Timothy J. O'Mara, MD<sup>1</sup>; Timothy J. Bray, MD<sup>1</sup>

<sup>1</sup>Reno Orthopaedic Clinic, Reno, Nevada, USA;

<sup>2</sup>Renown Regional Medical Center, Reno, Nevada, USA

**Background/Purpose:** In today's climate of cost containment in the healthcare industry, exploring generic implant alternatives represents an interesting area of untapped resources. Traditional implant companies develop their proprietary implants and are in direct competition with each other. However, unlike the pharmaceutical industry there are no generic equivalents available to help lower the implant costs to hospitals, insurance carriers, and patients. The purpose of this study was to examine the costs, implementation, and outcome of a cost containment program utilizing generic implants of equivalent quality.

**Methods:** The trauma panel at our institution adopted the use of generic 7.3-mm cannulated screws in January 2011. Despite a much lower cost, these screws were biomechanically tested as equivalent to major implant company products prior to the initiation of the project. Review of our trauma database identified patients with minimally displaced femoral neck fractures treated with generic 7.3-mm cannulated screws. These patients were compared to patients treated in a similar manner from 2010 with conventional implants. Chart review was undertaken to obtain basic demographic variables such as age, sex, and American Society of Anesthesiologists (ASA) status. Operative records were reviewed to identify any intraoperative complications, operative time, estimated blood loss, and need for conversion to arthroplasty. Radiographs were reviewed by a blinded author to record fracture type, healing time, screw cutout, varus collapse, and shortening. Hospital financial records were accessed to determine operative costs, and total hospital charges.

**Results:** Review of our institutional database identified 54 patients treated with generic 7.3-mm cannulated screws in 2011 and 58 treated with conventional implants in 2010. There were no significant differences in age, sex, ASA status, or fracture pattern between the two groups. No increase in operative time, estimated blood loss, complication rate, varus collapse, shortening, screw cutout, or conversion to arthroplasty was noted. Overall our hospital realized a 62% reduction in implant costs, resulting in \$44,226 savings for the calendar year.

**Conclusions:** Use of generic 7.3-mm cannulated screws in the treatment of femoral neck fractures has been a very successful endeavor at our institution. Hospital implant costs were decreased significantly without any associated increase in complication rate or radiographic outcome. This has profound implications for the treatment of trauma patients as patents have expired on many other products such as intramedullary nails, locking plates, and disposable items such as drill bits. Generic implant usage has the potential to markedly reduce operative costs in a manner similar to the generic pharmaceutical industry. As long as quality products are utilized, patient care is unaffected and cost savings can be realized. A portion of savings from such a change can be reinvested in the hospital trauma program to support OTA/AAOS position statement guidelines and positively affect the cost of hip fracture implants in the future.

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### A Retrospective Study of a Comprehensive Pain Protocol Using a Continuous Fascia Iliaca Compartment Block

Elizabeth Dulaney-Cripe, MD<sup>1</sup>; Scott J. Hadaway, DDS, MD<sup>2</sup>;

Carole Smith, CNS, BC, CCRN<sup>2</sup>; Brett C. LaFleur, MD<sup>1</sup>; G. Ryan Rieser, MD<sup>1</sup>;

Ryan D. Bauman, MD<sup>2</sup>; Michael J. Prayson, MD<sup>1</sup>; Richard T. Laughlin, MD<sup>1</sup>;

<sup>1</sup>Department of Orthopaedic Surgery, Wright State University, Dayton, Ohio, USA;

<sup>2</sup>Miami Valley Hospital, Dayton, Ohio, USA

**Background/Purpose:** Hip fractures account for 350,000 fractures annually, and the projected incidence is expected to exceed 6.3 million by 2050. Multiple strategies have been employed to reduce complications and hospital stay, including pre-emptive pain medications, nerve blocks, and prompt fixation of fractures. The use of one block, a fascia iliaca compartment block (FICB), has been shown to be effective in controlling pain in both hip arthroplasty and hip fracture. The purpose of our study is to evaluate the clinical effects of a continuous fascia iliaca block placed preoperatively in addition to a comprehensive pain protocol as measured by pain score, opioid consumption, delirium status, complications, hospital length of stay, disposition, and mortality.

**Methods:** All patients at our institution with a hip fracture after May 1, 2011 were given the option of having an FICB for pain control. Our goal is to enroll 200 consecutive patients. As soon as practical, an anesthesiologist placed the block in the emergency department or on the orthopaedic unit. The pain service monitored the block until the morning after surgery for treatment of the fracture. The catheter was removed on either postoperative day 1 or 2, depending on efficacy and pain control. During this time, the standard procedures for patients with hip fractures were implemented including the pre-emptive receipt of Celebrex and Lyrica, unless contraindicated. Documentation of pain scores, incidence of delirium, and medication administration including opioid consumption were performed. Other data collected included demographic data (age, gender, comorbidities), prehospitalization ambulatory status and living situation, length of stay, disposition, documentation of delirium, and any complications reported while an inpatient. The group receiving an FICB was compared to the previous consecutive 200 patients with a hip fracture admitted prior to the initiation of the fascia iliaca protocol. The two groups were compared on pain scores, opioid usage, complications, length of stay, disposition, and mortality.

**Results:** The FICB group (n = 129) did not differ from the comparison group (n = 200) on age, gender, visual analog pain scores on admission, prehospital ambulation status, and prehospital living situation. There were no differences in comorbidities including dementia, chronic obstructive pulmonary disease, and diabetes. The experimental group had less cardiovascular disease (58.6% vs 86.0%,  $P < 0.001$ ). Pain scores on postoperative day 0 were different, with the control group having a mean pain score of 3.23, and the experimental group having a mean pain score of 2.28 ( $P < 0.001$ ). Also, on postoperative day 1, the comparison's mean pain score was higher (3.05 vs 2.24 ( $P < 0.002$ )). On postoperative day 2, the two groups did not differ (comparison group mean = 2.86 and experimental group 2.41,  $P = 0.10$ ). There were no group differences in the amount of acetaminophen, hydrocodone, oxycodone, or dilaudid used. The comparison group used more morphine (mean = 18.6 mg vs 6.2 mg;  $P < 0.001$ ). The two groups did not differ on incidence of delirium, hospital length of stay, complication rate, disposition, and mortality.

See pages 97 - 144 for financial disclosure information.



**Conclusion:** Fascia iliaca continuous catheters have the potential to reduce the pain scores associated with hip fractures. The effectiveness of fascia iliaca nerve blocks in hip replacement has been demonstrated in several studies. However, no other studies have examined the effect of a continuous compartment block in a large hip fracture cohort.

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**Inferior Lag Screw Placement: Does the Tip-Apex Distance Really Matter?***Nikhil A. Thakur, MD; Wendell M. Heard, MD; Matt Young, BS;**Patrick M. Kane, MD; David Paller, MS; Christopher T. Born, MD;**Department of Orthopaedics, Brown University, Providence, Rhode Island, USA*

**Purpose/Hypothesis:** The tip-apex distance (TAD) concept was introduced by Baumgaertner et al to help treat peritrochanteric femur fractures. The TAD was recommended to be  $\leq 25$  mm to prevent cutout and loss of fixation. To achieve this, Baumgaertner et al advocated placement of the lag screw tip centered on both the AP and lateral radiographs. In a cadaveric study, we have found a low position on AP and centered on lateral position to be biomechanically superior. Clinically, our fixation technique frequently follows this placement strategy and often results in a TAD  $>25$  mm. We hypothesized that the lag screw low-center position results in a TAD  $>25$  mm but has a similar or lower cutout rate than the recommended center-center position of Baumgaertner et al.

**Methods:** A retrospective chart review was conducted on all patients between 2005 and 2010 who underwent fixation of peritrochanteric femur fractures (OTA 31-A1, A2) with cephalomedullary devices. Patient demographic data were collected. TAD was calculated using the same formula employed by Baumgaertner et al. Follow up information was obtained on each patient.

**Results:** 140 patients underwent cephalomedullary nail fixation for peritrochanteric femur fractures (OTA 31-A1, A2). Five patients were lost to follow-up. The remaining 135 patients had a final follow-up visit. Thirty-one patients had lag screw in low-center position (TAD of  $30 \pm 5.79$  mm) versus 65 patients with center-center position (TAD of  $22.12 \pm 6.42$  mm) ( $P < 0.001$ ). There were no cutouts in either group and all patients healed their fractures. 23 patients were in the center posterior position and the remaining 16 in other configurations (7 low anterior, 5 low posterior, and 4 center anterior). There was one cutout in the center-posterior (TAD = 29mm) and one in the center-anterior (TAD = 20 mm), respectively. Other patient factors did not affect the rates of cutout on regression analyses.

**Conclusion:** Based on our hypothesis, the low-center group had a TAD of  $\sim 30$  mm and should have resulted in higher cutout rates than the center-center group based on the TAD theory. However, there were no cutouts in the low-center group. Of the two cutouts seen in the cohort, one had a TAD lesser and one had a TAD greater than 25 mm. These lag screws were placed in the center position on the AP view and either anterior or posterior positions on the lateral view. Based on this study and our cadaveric work, we feel the optimal position of the lag screw to be low on the AP and centered on the lateral radiograph. This may result in a TAD  $>25$  mm but does not result in increased cutouts with this lag screw position.

**Re-Engineering the Management of Patients with Fragility Hip Fractures**

*C. Michael LeCroy, MD; Martha Hoskyns, RN, BSN, MHA; Christina McQuiston, MB ChB; Mission Health System, Asheville, North Carolina, USA*

**Background/Purpose:** Nearly 300,000 Americans sustain a fragility hip fracture each year. An average of 24% of hip fracture patients aged 50 years and over die in the first year following their hip fracture. The purpose of this study was to design and implement a geriatric hip fracture program that would result in standardized hospital care, fewer complications, reduced length of stay, reduced hospital costs, and improved patient education and follow-up care.

**Methods:** Mission Hospital is an 800-bed tertiary referral center and Level II trauma center located in Asheville, NC. 41 orthopaedic surgeons are on staff, and Mission performs the highest number of hip fracture repairs in North Carolina with approximately 500 cases annually. A program was implemented in 2009 for collaborative management of hip fracture patients, with preoperative hospitalist consultation on all patients over age 64 with a fragility hip fracture. The preoperative process was streamlined with concentrated efforts to get patients to the operating room as soon as possible. The patients were comanaged postoperatively, with the hospitalists focused on reducing medical complications, improving pain management, and reducing delirium. Outcomes were followed prospectively and compared to historical data on similar patients treated at our institution.

**Results:** Implementation of the hip fracture program resulted in decreased door to operating room times, with the average time falling below 24 hours. The average length of stay for hip fracture patients dropped from 6.4 to 5.1 days from 2008 to 2009. The readmission rate dropped from 10% to 8%, and the mortality rate dropped from 2.35% to 0.9% from 2008 to 2009. The hospital net income per case for hip fracture patients improved from -\$2100 to +\$800 over the same time span.

**Conclusions:** Collaborative management of patients with fragility hip fractures between orthopaedists and hospitalists does result in improved patient outcomes. Implementation of a geriatric hip fracture program can result in decreased complications and costs of hospital care.

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### **Δ Management of Hip Fracture Patients Using a Standardized Perioperative Approach Combined With a Medical Home (MH) Primary Care Model: A New Standard for Better Outcomes?**

*Jove H. Graham, PhD; Thomas R. Bowen, MD; Kent A. Strohecker, MS;  
Kaan S. Irgit, MD; Wade R. Smith, MD;  
Geisinger Health System, Danville, Pennsylvania, USA*

**Background/Purpose:** Hip fracture patients continue to experience high morbidity and mortality rates in the first postoperative year, and significant complications occur most often after discharge. Postdischarge care management using a Medical Home (MH) model attempts to reduce such complications, particularly in patients with medical comorbidities, by using nurse case managers to coordinate the transition from hospital to home and subsequent care. Case managers use early telephone outreach, medication reconciliation, social support assistance, and ensure timely follow-up with primary care physicians in the months immediately following surgery. We compared rates of mortality, hospitalizations, emergency department (ED) visits, and prescription orders between two prospective cohorts of hip fracture patients, both managed with identical perioperative protocols and one group subsequently managed via MH. We hypothesized that the best outcomes would occur in patients managed initially with a standardized approach, early surgery, and subsequent MH management.

**Methods:** We analyzed 6- and 12-month outcomes from a prospective cohort of 194 patients who were surgically treated for hip fracture from 2010 to 2011 at two hospitals, half of whom received MH care. Mean age was 82 years (range, 62-100), and 28% of patients were male. MH patients were matched to patients who received identical in-hospital protocols but did not receive MH, on the basis of surgery date ( $\pm 90$  days), sex, age, and major comorbidities using a 1:1 ratio and propensity scoring methods. Mortality rates, hospitalizations, ED visits, and prescriptions per patient were compared between the two cohorts using log-rank survival analysis and Poisson regression (expressed as odds ratios [OR]) with  $P < 0.05$  considered significant.

**Results:** At 6 months postoperatively, MH patients had a significantly lower mortality rate than patients receiving standard care (11 vs 26%, respectively;  $P < 0.01$ ). At 12 months, a difference persisted (23 vs 30%,  $P = 0.12$ ), although it was no longer statistically significant. Differences in all-cause hospitalizations, ED visits, and prescription orders per patient were similar at 12 months (OR 0.9, 1.3, and 1.4;  $P = 0.83, 0.42, \text{ and } 0.16$ , respectively).

**Conclusion:** Patients receiving aggressive postdischarge care from a Medical Home program showed significant benefits in terms of reduced mortality and trends toward reduced hospitalizations in the time period following hip fracture. Postsurgical care of elderly, multicomorbid patients is complex, but these results suggest that ongoing MH management can benefit patients and may reduce costs.

**Fate of Hip Stems After Operative Fixation of Periprosthetic Femoral Shaft Fractures**

*Mark J. Jo, MD; Jacob X. Didesch, MD; David S. Merriman; Christopher M. McAndrew; Michael J. Gardner, MD; William M. Ricci, MD; Washington University School of Medicine, Saint Louis, Missouri, USA*

**Purpose:** The effect of periprosthetic fracture on the survivorship of hip arthroplasty stems is unknown. The objective of this study was to evaluate the long-term outcomes of patients who sustained a fracture about a hip arthroplasty stem and were treated with open reduction and internal fixation (ORIF). The focus was on revision rates of the femoral stem. Our null hypothesis was that a periprosthetic fracture about a femoral stem treated with ORIF would not lead to the need for revision arthroplasty.

**Methods:** 86 consecutive patients who underwent operative fixation following a periprosthetic fracture of the femoral shaft about a hip arthroplasty stem between 1998 and 2010 were studied retrospectively. Patients were excluded if they had previous surgery for infection, if their immediate postoperative course was complicated by infection, if the fracture was iatrogenic during their arthroplasty procedure, or if the stem was found to be loose at the time of fracture treatment and was treated with revision arthroplasty. 22 patients (average age at the time of injury 71.7 years; range, 23.6-95.5) with greater than 1-year follow-up (average 4.2 years; range, 1.2-9.7) remained after applying exclusion criteria. Of the 22 patients, 20 had fractures about a total hip arthroplasty and 2 were about a hemiarthroplasty. 13 patients had a press-fit stem and 9 were cemented. Using the Vancouver classification, there were 15 B1 and 7 C type fractures. 21 patients had a fracture about after a primary arthroplasty and one after a revision. All other patients were treated with a plate, screw, and cable construct and five patients also had bone grafts. All of these five cases included a strut allograft, cancellous allograft was added to one case, and one case added both cancellous allograft and bone morphogenetic protein-2 (BMP-2). Patients or their families were interviewed to obtain information regarding outcomes, complications, and subsequent surgical procedures relevant to their periprosthetic fractures.

**Results:** The average lifespan of the hip stems at the time of fracture was 8.6 years. Of the 22 patients, 20 patients' fractures healed following the initial ORIF procedure. One patient had failure of fixation and was treated nonoperatively to union; one patient did not heal the fracture after three attempts and was treated with a proximal femoral replacement. Of the 20 patients who were treated to union, the average lifespan of the femoral component was 13.6 years with a range of 2.1 to 35.1 years. No patient with union of the fracture required revision of the stem for loosening.

**Conclusion:** Periprosthetic femur fracture about a hip stem does not appear to lead to premature stem loosening. In our series of 22 periprosthetic fractures, there was no need for revision arthroplasty after successful fracture treatment. Patients who did require revision of their femoral stem were those who had a postoperative courses complicated by nonunion.

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### Assessment of Radiographic Fracture Healing in Patients With Operatively Treated Femoral Neck Fractures

Brad A. Petrisor, MD, FRCSC<sup>1</sup>; Olufemi R. Ayeni, MD, FRCSC<sup>1</sup>; Simrit Bains, MA<sup>1</sup>;

Rajesh Chakraverty, MD, FRCSC<sup>2</sup>; Meg Chiavaras, MD, PhD, FACP, FRCPC<sup>3</sup>;

Hema N. Choudur, MBBS, FRCPC<sup>3</sup>; Naveen Parasu, MBBS, FRCR, FRCPC<sup>3</sup>;

**Mohit Bhandari, MD, PhD, FRCSC<sup>1</sup>**; on behalf of the Assessment Group for Radiographic Evaluation and Evidence (AGREE) Study Group;

<sup>1</sup>Department of Surgery, McMaster University, Hamilton, Ontario, Canada;

<sup>2</sup>Department of Surgery, Toronto Western Hospital, Toronto, Ontario, Canada;

<sup>3</sup>Department of Radiology, McMaster University, Hamilton, Ontario, Canada

**Purpose:** The reliability of assessing fracture healing in femoral neck fractures has not been adequately addressed in both research and surgical practice. The accurate assessment of fracture healing is vital in both patient care and in outcomes of clinical research. The purpose of the present study was to determine the reliability of fracture healing assessment and the validity of a novel Radiographic Union Scale for Hip (RUSH) fracture score.

**Methods:** A panel of 6 reviewers (3 orthopaedic surgeons and 3 radiologists) independently assessed fracture healing for 150 femoral neck fractures at two separate occasions with a time lapse of 4 weeks to determine interrater and intrarater reliability. Assessment was performed using radiographs for each case at a single time point at various stages of healing. The RUSH score was developed based on the existing criteria and definitions of hip fracture healing, and as such incorporated the assessment of callus bridging and disappearance, trabecular consolidation, and trabecular disappearance. Reviewers used this to score each fracture on a scale from 10 to 30. This would help to determine the validity of using this system to quantify hip fracture healing.

**Results:** Using subjective assessment of fracture healing, the interrater agreement between all reviewers for fracture healing was low (intraclass correlation coefficient [ICC] = 0.32, 95% confidence interval [CI]: 0.20-0.46) with no significant difference between the orthopaedic surgeon and radiologist groups (0.27 vs 0.31). There was higher agreement for fracture healing using the RUSH score (ICC = 0.63, 95% CI: 0.34-0.79) when compared to physician assessment of healing (ICC = 0.37, 95% CI: 0.10-0.59). Intrarater agreement was consistently high across all measures for both surgeons and radiologists. The RUSH score and medial cortex bridging correlated well with the overall assessment of healing (Pearson correlation ( $r$ ) = 0.868 and 0.643, respectively). Less than 2 weeks after surgery, 6 of 7 (85.7%) fractures were deemed healed by reviewers.

**Conclusion:** In the absence of time of radiographic evaluation, the level of agreement between and within orthopaedic surgeon and radiologist reviewers in the assessment of fracture healing is low, although intrarater agreement is high. Assessments were improved with the use of a simple radiological checklist (RUSH). Studies evaluating reliability and accuracy of healing with clinical information and temporal evaluation are needed and may further improve agreement.

See pages 97 - 144 for financial disclosure information.

### New Camera-Free Fluorobased Navigation System for Accurate Lag Screw Positioning: Comparison of Conventional Versus Navigated Postoperative Outcome

Rainer H. Burgkart, MD, PhD<sup>1</sup>; Heiko Gottschling, PhD Inf<sup>1</sup>; Manuel Schroeder, Dipl Inf<sup>1</sup>; Nils Reimers, Dipl Ing<sup>2</sup>; Heye Janssen<sup>3</sup>; Arndt P. Schulz, MD, PhD, MRCS<sup>3</sup>;

<sup>1</sup>Clinic for Orthopaedics and Traumatology, Technische Universität München, München, Germany;

<sup>2</sup>Stryker Osteosynthesis, Schönkirchen, Germany;

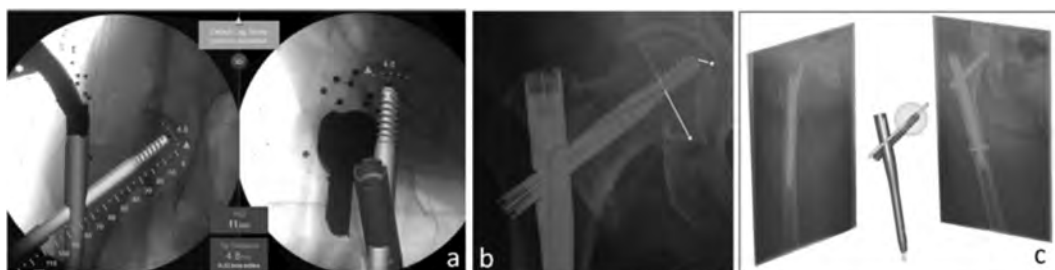
<sup>3</sup>Department Trauma & Orthopaedics, University Hospital Lübeck, Lübeck Germany

**Purpose:** Outcome of pertrochanteric fracture treatment is essentially dependent on the positioning of the hip screw in the femoral head. Well-established standards indicate the best outcomes are related to a center-center position in the head and a tip-apex distance (TAD) of <25 mm. The goal of this study was to compare the accuracy of the conventional technique with a new camera-free navigated lag screw positioning using TAD and additionally a three-dimensional (3D) inverse reconstruction method (IRM) visualizing the femur head sphere and lag screw in 3D for the 3D distance between tip-head surface in the screw axis (TSD).

**Methods:** The study is based on the first 12 consecutive patients (median age 84 years, interquartile range [QR] 28 years) treated with a Gamma3 Nail (Stryker) using a new camera-free navigation system (FluoroMap, Stryker) compared to 12 patients (median age 86.5 years, IQR 13 years) conventionally treated. Both groups were stratified regarding age ( $P = 0.897$ ), sex ( $P = 1.000$ ), and body mass index ( $P = 0.160$ ). All patients had pertrochanteric fractures and were operated only by experienced surgeons. For supporting the lag screw implantation, FluoroMap visualizes for the surgeon a virtual 3D model of the lag screw and the femur head surface accurately projected in both standard fluoroimages (AP + lateral) according to the position of the targeting arm (Figure 1a). Therefore the surgeon can directly plan in 3D the type of nail (CCD [caput-collumn-diaphysis] angle), length, and position of the lag screw. Because of a calibration disc mounted to the C-arm, standard C-arms just as conventional surgical tools can be used. To analyze the TAD (Figure 1b) and—also in the conventional group—the 3D position of the lag screw in regard to the 3D femoral head surface a software based IRM (developed at TUM [Technische Universität München]) was used and corrected for magnification. The IRM application utilizes the known accurate implant dimensions in both radiographic projections at the time of surgery (Figure 1c). For statistical analysis the Wilcoxon test and Fisher exact test ( $P < 0.05$ ) were used.

**Results:** The median TAD of the conventionally treated group (CG) was 23.8 mm (IQR 7.2, range 17.7-35.5) and thus significantly higher than in the navigated group (NG) with a median TAD of 16.8 mm (IQR 4.4, range 10.1-32.7) ( $P = 0.002$ ). The known critical TAD value of 25 mm or higher was found in 4 patients of CG due to substantial eccentric screw positions and only in 1 patient of NG with an accurate central screw position, but a 16-mm too short screw. The Parker's quotient as a measure of the lag screw axis to the head center was in the anterior-posterior direction with 8% (range, 2%-23%) deviation from the optimal 50% in CG, significantly higher compared to 2% in NG (range, 0-11%) ( $P < 0.003$ ). For the superior-inferior direction both groups had equal, very central positions. Finally the 3D evaluation

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**Figure 1.**

a, FluoroMap System provides a projected 3D model of implant and femur head surface;  
 b, measurements of TAD and Parker's quotient;  
 c, inverse 3D reconstruction of implant and femur features (head, CCD, etc) from two standard x-rays as basis for all 3D measurements.

of the tip to head surface (TSD) affirmed the two-dimensional results. The median TSD of CG was 9.2 mm and thus significantly higher than in the NG with 5.7 mm ( $P < 0.005$ ).

**Conclusion:** To prevent cut-out of sliding hip screws, the most important surgical aim must be an optimal central position of the lag screw with a minimal TAD value. The present study could demonstrate that with a new camera-free navigation system, a higher rate of central positions of the lag screw with significant smaller TAD values compared to the conventional technique can be achieved. With the supporting device, only 1 TAD value was over the critical 25-mm level compared to 4 in the conventional group. Besides the two-dimensional x-ray evaluation, the implemented 3D analyzing tool (IRM) could demonstrate the optimized lag screw positions in the navigated group also 3D with a significantly shorter TSD in the navigated group. Although larger cohorts have to be analyzed, these first results of the new navigation system are already very promising and the new system can be in the future an additional support for surgeons minimizing the cut-out risk by optimized lag screw positioning.



**Are Dedicated Geriatric Hip Fracture Centers Justified Economically?**

*R. Carter Clement, MD, MBA; Jaimo Ahn, MD, PHD; Samir Mehta, MD;*

*Michael Maiale, MBA; Joseph Bernstein, MA, MD;*

*University of Pennsylvania Department of Orthopaedics, Philadelphia, Pennsylvania, USA*

**Purpose:** The management of geriatric hip fractures in a protocol-driven center can improve outcomes and reduce costs. Nonetheless, this approach has not spread as broadly as the effectiveness data would imply. One possible explanation is that the investment necessary to develop such a center is not perceived as financially worthwhile. The purpose of this study is to determine the economic justification for establishing dedicated hip fracture centers (HFCs).

**Methods:** A financial model was built to estimate profit as a function of costs, reimbursement, and patient volume in three settings: an average U.S. hip fracture program, an especially efficient center, and an academic hospital without a specific hip fracture program. Data sources included published series, government reports, and cost reports at our institution. Results were tested with sensitivity analyses. Lastly, a local market analysis was conducted to assess the feasibility of supporting dedicated hip fracture centers at volumes necessary for profitability.

**Results:** Hip fracture treatment generates economic losses at low volumes. Such care becomes profitable when the annual caseload exceeds 72, assuming costs characteristic of a typical HFC. The threshold of profitability is 49 cases/year for a low-cost HFC and 151 for an academic hospital. The largest determinant of profit is reimbursement, followed by costs and volume. In our home market, 168 hospitals offer hip fracture care, yet 85% fall below the 72-case threshold. Only 7 hospitals (4%) treated at least 151 hip fractures.

**Conclusion:** HFCs can be profitable, provided the center has a sufficiently large patient volume. However, most hospitals lack this volume and are likely losing money by offering hip fracture care. Thus, most hospitals would benefit financially from the consolidation of hip fracture care at dedicated regional HFCs. Most U.S. metropolitan areas have adequate volume to allow several such centers to operate profitably. The implications of HFCs for surgeons is not addressed by this analysis, but is worthy of future consideration as well.

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### Mortality of Femoral Neck Fractures in the Elderly Based on Charlson Comorbidity Index and Treatment Modality

*Adam Shar, MD; Timmothy Randell, MD; Christopher D. Chaput, MD; Daniel C. Jupiter, MD; Kindyle L. Brennan, PhD; Zachary T. Hubert, BS; Robert A. Probe, MD; Michael L. Brennan, MD; Scott and White Memorial Hospital, Temple, Texas, USA*

**Purpose:** Femoral neck fractures constitute significant mortality in the elderly population. No study to date has assessed mortality in relation to comorbidity status and treatment modality in this population. The purpose of the study is to determine if the Charlson Comorbidity Index (CCI) has prognostic value in assessing mortality in patients with femoral neck fracture, with and without taking surgery type into account, and to determine a cutoff for CCI above which the hazard ratio for death increases significantly.

**Methods:** This retrospective cohort study included patients aged  $\geq 60$  years with femoral neck fractures from low-energy trauma at a Level I trauma center between 1998 and 2009, netting 1525 cases in 1440 patients. Data collected include demographics, CCI, surgery type (closed reduction and percutaneous pinning [CRPP], hemiarthroplasty [HA], total hip arthroplasty [THA]), and death date. Kaplan-Meier estimates were used to determine the relationship between CCI and mortality rates, and to identify a CCI at which the hazard ratio for death changed significantly. In a post hoc subanalysis, patients were categorized into 3 groups based on severity of CCI (low, 2-4; medium, 5-6; high,  $\geq 7$ ). In each group, mortality at 1 month, 6 months, 1 year, and 2 years is calculated, with and without taking surgery type into account. Cox proportional hazards regression and  $\chi^2$  tests were used where appropriate.

**Results:** Of 1,525 fractures, 745 underwent CRPP, 749 underwent HA, and only 40 had THA. CCI was a significant factor in mortality ( $P < 0.001$ ), and increase of CCI by 1 increased the hazard ratio for death by 1.35 (95% confidence interval [CI] 1.30-1.40). At  $CCI \geq 11$ , the hazard ratio for death increased 5-fold; however, only 6 cases (0.4%) met this criterion. In an analysis based on 3 groups of CCI, 1-month mortality throughout the entire study population in order of low, medium, and high CCI groups were 2%, 7%, and 16%, respectively ( $P < 0.001$ ); at 6 months; they were 7%, 19%, and 34% ( $P < 0.001$ ); at 1 year; they were 10%, 24%, and 46% ( $P < 0.01$ ); at 2 years, they were 17%, 35%, and 58% ( $P < 0.001$ ). A subset analysis that controlled for surgery type revealed a similar increase in mortality with increasing CCI. Most notably, mortality is greatest in the high CCI group at 2 years (60% for CRPP and 58% for HA).

**Conclusion:** Increasing CCI was associated with increased mortality after surgical intervention for femoral neck fractures. This association remained significant even after controlling for surgery type. Assessment for the THA group is limited secondary to low power.

**The National Hip Fracture Database in England, Wales, and Northern Ireland: Results From 50,000 Patients Treated in a 1-Year Period***Christopher G. Moran; R. Wakeman; C. Currie;**M. Partridge; Keith M. Willett, MD;**British Orthopaedic Association and British Geriatrics Society*

**Background/Purpose:** The National Hip Fracture Database (NHFD) is a prospective audit of hip fracture care and secondary fracture prevention in England, Wales, and Northern Ireland (population 60 million). It is clinically led and web-based and collects a standard data set with central data storage and analysis. It was launched in 2007 and national participation has steadily increased. All 191 hospitals providing acute hip fracture care are now registered; the database holds records of 147,000 patients and collects data on 5000 new patients per month. This study reports the results of 53,443 patients aged >59 years admitted with a hip fracture between April 1, 2010 and March 31, 2011. This is a study of the entire population and, as such, provides Level I epidemiological evidence.

**Methods:** The total number of data fields documenting the 53,443 cases is 1,081,670, of which 998,435 (92.3%) were complete. Data is cross-referenced with the National Office of Statistics, which hold records of all deaths in the United Kingdom and this allows 100% follow-up for mortality statistics. The average age is 80 years and 21% of patients are aged >90 years. 73.9% are female. 74.1% were admitted from their own home and, before injury, 45.2% could walk without aid and 24.9 used a single stick. The fracture types were: undisplaced intracapsular (11.4%), displaced intracapsular (46.3%), intertrochanteric (33.8%), and subtrochanteric (5%). Displaced subcapital fractures were treated with arthroplasty and 68.2% of these were cemented. 83.6% of intertrochanteric fractures were treated with a sliding hip screw.

**Results:** A subgroup analysis was performed on a group of 28 hospitals with established NHFD participation, with data available from April 2008 to March 2011 and a high level of case reporting and data completeness. This subgroup included a total of 30,022 patients (9574 from April 2008 to March 2009; 10,075 from April 2009 to March 2010; 10,400 from April 2010 to Mar 2011) and was used to analyze trends in 6 care quality indicators. During this 3-year period, surgery within 36 hours of admission increased from 54% to 68% and surgery within 48 hours from 70% to 83%. Preoperative assessment by an orthogeriatrician increased from 28% to 55%, falls assessment from 52% to 85%, and osteoporosis assessment and treatment from 65% to 90%. These changes were mirrored by a 15% reduction in 30-day mortality from 9.4% to 8.0%. All of these changes were highly statistically and clinically significant.

**Conclusions:** We conclude that a web-based National Hip Fracture Database is an effective method of clinical audit. It allows the development of national benchmarks and performance indicators for individual units. Most importantly, it is a key catalyst in raising both the quality and cost-effectiveness of care for these frail, elderly patients.

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**The Hidden Blood Loss After Hip Fracture**

*Samuel G. Molyneux, MSc, MRCS; G. Brown, MRCS; Timothy O. White, MD, FRCS(Orth);  
New Royal Infirmary of Edinburgh, Edinburgh, Scotland, United Kingdom*

**Background/Purpose:** A significant proportion of the blood loss related to hip fractures occurs prior to surgery. Despite advances in surgical and anesthetic techniques the mortality after hip fracture has not significantly changed in the last 40 years. Preoperative anemia is a risk factor for perioperative death. Identifying patients at risk of preoperative anemia can facilitate appropriate medical optimization. This study attempts to quantify the blood loss associated with the initial hip injury prior to surgery.

**Methods:** This was a prospective study. All patients with a diagnosis of hip fracture presenting to our unit were included. Admission information included: fracture classification, hemoglobin (Hb), electrolytes, and urea on admission, length of time between injury and presentation, domiciliary status, drug history, and patient comorbidities. All patients then had a repeat blood test (Hb, urea, and electrolytes) in the anesthetic room immediately prior to surgery. Patients with a preinjury diagnosis of anemia, on anticoagulation, and with gastrointestinal bleeds were excluded from this study.

**Results:** 83 hip fracture patients were included in the study. There were 35 intracapsular fractures and 48 extracapsular. All patients underwent operation within 48 hours. The mean age was 76 years (range, 53-91). There were 56 women and 27 men. There was a universal fall in preoperative Hb (range, 2.2-33 g/L). The mean Hb drop in the extracapsular and intracapsular fracture groups was 13.8 g/L and 8.2 g/L, respectively ( $P < 0.05$ ). The only predictor of fall in Hb was age, with younger patients suffering a larger fall in Hb than older patients (mean Hb drop = 16.1 in <70 years, 12 in 70 to 79 years, 8.3 in 80 to 91 years). There were no corresponding changes in urea or electrolytes to suggest this was a purely dilutional effect from fluid administration.

**Conclusions:** Hip fracture patients have a large drop in hemoglobin that is associated with the initial trauma rather than the operation. This highlights the need for anesthetic and orthopaedic staff to be vigilant to the risk of preoperative anemia in this cohort of frail patients even when the initial hemoglobin is apparently normal.

## **Surgical Fixation of Vancouver Type B1 Periprosthetic Femur Fractures: A Systematic Review**

*Nilooofar Dehghan, MD; Aaron Nauth, MD; Bill Ristevski, MD;*

*Michael D. McKee, MD; Emil H. Schemitsch, MD;*

*Division of Orthopaedics, St. Michael's Hospital, University of Toronto,  
Toronto, Ontario, Canada*

**Purpose:** Periprosthetic fractures are a devastating complication of total hip arthroplasty. Type B1 periprosthetic fractures occur at the tip of a stable implant, and are usually treated with open reduction and internal fixation (ORIF). However, many different fixation techniques have been described, and there is a lack of consensus on the optimal technique. Current treatment strategies include the use of cortical strut allografts alone, cable plates or compression plates with/without cortical strut allografts, and locking plates. This systematic review of the literature investigates and compares the outcomes of these different treatment strategies.

**Methods:** A literature review was conducted focusing on surgical fixation of type B1 periprosthetic fractures. Two independent authors reviewed the potential studies, and 19 studies were included for final analysis. These were all retrospective case series, with no randomized controlled studies or prospective cohort trials found in the literature. Studies were analyzed and categorized depending on the method of fixation: group 1, ORIF with strut allografts alone; group 2, ORIF with cable plate/compression plates alone; group 3, ORIF with cable plate/compression plates and cortical strut allograft; and group 4, ORIF with locking plates. Data analysis was performed comparing rates of nonunion, malunion, hardware failure, infection, reoperation, and total complications.

**Results:** 19 studies were identified with a total of 280 patients at the final analysis. The rate of total complications for all patients (N = 280) was 34%: nonunion, 5%; malunion >5°, 6%; hardware failure, 5%; infection, 5%; and reoperation 12%. These varied between the four different fixation groups. Cortical struts allografts alone were used in 26 patients, cable plate/compression plates were used in 149 cases, cable plate/compression plates with cortical strut allografts were used in 42 cases, and locking plates were used in 63 cases. Locking plates had a significantly higher rate of total complications compared with the other three groups. The rate of total complications for locking plates (group 4) compared with the other three groups were as follows: versus group 1, 48% vs 19%,  $P = 0.02$ ; versus group 2, 48% vs 30%,  $P = 0.02$ ; versus group 3, 48% vs 29%,  $P = 0.04$ . There was also a significantly higher rate of hardware failure of locking plates compared with group 2 (14% vs 3%,  $P = 0.007$ ), and a trend toward higher rate of hardware failure compared with group 3 (14% vs 2%,  $P = 0.07$ ). Compared with group 1, locking plates had a trend towards higher rates of nonunion (4% vs 11%,  $P = 0.06$ ) and reoperation (19% vs 4%,  $P = 0.10$ ). Locking plates showed a trend toward a lower rate of malunion compared with group 1 (2% vs 12%,  $P = 0.08$ ) and group 3 (2% vs 10%,  $P = 0.10$ ).

**Conclusion:** This systematic review suggests that with regard to fixation of type B1 periprosthetic femur fractures, locking plates have significantly higher rates of total complications

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compared with the other three fixation options, and a significantly higher rate of hardware failure compared to cable plate/compression plates. There are limitations to this study, and further investigation with high-quality randomized controlled trials is needed to further assess these outcomes.

**Radiographic Identification of Atypical Subtrochanteric and Femoral Shaft Fractures***Lise A. Leveille, MD<sup>1</sup>; Penny Brasher, PhD<sup>2</sup>; Pierre Guy, MD<sup>1</sup>; Peter J. O'Brien, MD<sup>1</sup>;**<sup>1</sup>Department of Orthopaedics, University of British Columbia, Vancouver, British Columbia, Canada;**<sup>2</sup>Department of Statistics, University of British Columbia, Vancouver, British Columbia, Canada*

**Background/Purpose:** Atypical subtrochanteric (ST) and femoral shaft (FS) fractures (OTA Fracture Compendium type 32-A3) have been increasingly reported in the literature. Their association with long-term bisphosphonate use has been debated. Smaller case series and case-control studies have suggested an association between atypical ST/FS fractures and long-term bisphosphonate use. Some larger, population-based studies have not supported this association. In the majority of these larger studies, no radiographic review was completed. The purpose of this study was to first, identify the proportion of atypical fractures in patients admitted to a Level I trauma center with a low-energy ST/FS fracture using the American Society for Bone and Mineral Research (ASBMR) radiographic criteria. Second, we sought to quantify the interobserver reliability of using this method for identification of atypical ST/FS fractures. Finally, we wanted to identify the proportion of atypical ST/FS fracture subjects with a history of bisphosphonate exposure.

**Methods:** A prospectively collected trauma database was used to identify patients greater than 55 years of age presenting to a Level I trauma center with a low-energy ST/FS fracture between January 2000 and February 2011. Exclusion criteria were clinical or radiographic evidence of active malignancy, periprosthetic fracture, history of metabolic bone disease, or fracture outside the defined region of interest. Digital radiographs were assessed by three blinded, independent reviewers and categorized as either atypical or nonatypical based on the ASBMR radiographic criteria for atypical ST/FS fractures. A chart review was completed on all atypical fractures.

**Results:** 358 ST/FS fractures were identified. Exclusion criteria were met in 195 fractures. 39 fractures were radiographically categorized as atypical, with an interrater reliability (concordance) of 96% and kappa of 0.92. Of the atypical ST/FS fractures, 10 were excluded after chart review for history of metastatic cancer, high-energy mechanism of injury, or Paget disease. Of the remaining 29 atypical fractures in 26 subjects, 86% were taking a bisphosphonate at the time of fracture. The average duration of bisphosphonate use was 8.2 years.

**Conclusion:** The majority of low-energy ST/FS fractures are not atypical fractures according to the ASBMR radiographic criteria. Use of database-identified cohorts, without radiographic review, results in overinclusion and masking of any association between atypical femoral fractures and long-term bisphosphonate use. Three independent reviewers using the ASBMR radiographic criteria is a reliable means of identifying atypical ST/FS fractures. In this series of atypical ST/FS fractures, the majority had a history of bisphosphonate exposure, which is consistent with previously reported case series.

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### **Percutaneous Plating of the Distal Femur: Risk of Injury to the Perforating Branches of the Profunda Femoris Artery**

*Adam Baker, MD; Brent Roster, MD; Amer J. Mirza, MD;  
Oregon Health & Sciences University, Portland, Oregon, USA*

**Purpose:** Our objective was to map the anatomic course of the perforating branches of the profunda femoris artery to determine the risk of injury during percutaneous plate insertion along the lateral femoral shaft.

**Methods:** 37 adult fresh-frozen cadaveric lower extremity specimens were instrumented with precontoured distal femoral periarticular plates. The specimens were dissected and the location, diameter, number, and course of the deep perforating arteries and their branches were noted with respect to the lateral femoral cortex and distance from the articular surface of the lateral femoral condyle. The incidence of perforating artery injury was determined and quantified with respect to plate hole number.

**Results:** There were an average of 5.1 (SD 1.2) perforating arteries (PAs) per cadaveric limb. Arteries were numbered numerically from distal to proximal with the most distal perforating vessel as number 1. The average diameter of each PA was 0.67 cm (0.33) for PA-1, 0.72 cm (0.41) for PA-2, 1.04 cm (0.60) for PA-3, 1.02 cm (0.55) for PA-4, 0.87 cm (0.53) for PA-5, 0.69 cm (0.35) for PA-6, and 0.84 cm (0.23) for PA-7. At the level of the midsagittal femur cortex, 52% of PAs had 0 branches, 2% had 1 branch, 31% had 2 branches, 13% had 3 branches, and 3% had 4 branches. The distance from the midportion articular surface of the lateral femoral condyle to each PA in both centimeters and percentage of total femur length averages 10.51 cm (24%) for PA-1, 17.97 cm (41%) for PA-2, 22.04 cm (52%) for PA-3, 25.28 cm (54%) for PA-4, 26.66 cm (60%) for PA-5, 29.21 cm (66%) for PA-6, and 29.09 cm (66%) for PA-7. The frequency of injury to the different PAs was 85% PA-1, 84% PA-2, 81% PA-3, 84% PA-4, 80% PA-5, 82% PA-6, and 100% for PA-7. The corresponding holes in the 16-hole Synthes LCP plate were hole numbers 3, 4 for PA-1, hole numbers 6, 7 for PA-2, hole numbers 8-10 for PA-3, hole numbers 11, 12 for PA-4, hole numbers 12, 13 for PA-5, hole numbers 13, 14 for PA-6, and hole numbers 13-15 for PA-7. The corresponding holes in the 18-hole Zimmer 5.5-mm Locking Distal Femur Plate were hole number 3 for PA-1, hole numbers 5, 6 for PA-2, hole numbers 8-11 for PA-3, hole numbers 11, 12 for PA-4, hole numbers 12, 13 for PA-5, hole numbers 13, 14 for PA-6, and hole numbers 13-15 for PA-7. The corresponding holes in the 16-hole Smith & Nephew 4.5-mm PERI-LOC Distal Femur Plate were hole numbers 4, 5 for PA-1, hole numbers 6, 7 for PA-2, hole numbers 9-11 for PA-3, hole numbers 11, 12 for PA-4, hole number 13 for PA-5, hole numbers 13, 14 for PA-6, and hole numbers 14, 15 for PA-7.

**Conclusion:** The deep perforating branches of the profunda femoris are at risk of injury during submuscular minimally invasive plating techniques for stabilization of distal femoral fractures. Our study demonstrated a consistent number and pattern of perforating branches of the profunda femoris artery. We noted an average of 80% injury rate to the perforating arteries or one of their branches. An understanding of the anatomic course of the profunda femoris perforating arteries can be used during minimally invasive plating techniques of the distal femur.

See pages 97 - 144 for financial disclosure information.



### **Ipsilateral Femoral Neck and Shaft Fractures: Results of Treatment With Hip Screws and a Retrograde Intramedullary Nail**

**Robert F. Ostrum, MD<sup>1</sup>; Paul Tornetta, III, MD<sup>2</sup>; J. Tracy Watson, MD<sup>3</sup>;  
Anthony Christiano<sup>2</sup>; Emily Vafek, MD<sup>4</sup>;**

<sup>1</sup>Cooper University Hospital, Camden, New Jersey, USA

<sup>2</sup>Boston University Medical Center, Boston, Massachusetts, USA;

<sup>3</sup>Saint Louis University, Saint Louis, Missouri, USA;

<sup>4</sup>Wake Forest Baptist Medical Center, Winston-Salem, North Carolina, USA

**Purpose:** Ipsilateral femoral neck and shaft fractures are not common injuries but can be a difficult entity to treat. Currently, sliding hip screw or multiple cannulated screw fixation of the proximal femoral fracture followed by retrograde intramedullary nailing is considered the treatment of choice. This study reviews our experience using this technique.

**Methods:** This is a consecutive series, retrospective review from February 2003 to April 2011 of all ipsilateral femoral neck and shaft fractures treated at three Level I trauma centers. They were all treated with a sliding hip screw (SHS), 95° hip screw (DCS), or cannulated screws (CS) proximally followed by retrograde intramedullary nailing. Patients were followed until clinical union and complications, range of motion, and secondary procedures were examined.

**Results:** There were 68 patients identified; 3 were lost to follow-up, leaving 65 patients in the cohort. There were 17 females, 48 males, 30 left, and 35 right femoral fractures. The average age was 37.3 years and follow-up ranged from 16 weeks to 52 months. The proximal fractures (OTA 31A,B) included: 1 subtrochanteric, 12 intertrochanteric, 35 basicervical, 15 transcervical, and 2 subcapital. There were 2 DCS and 38 SHS implants, and 25 patients had CS as their treatment. 17 shaft fractures were open. Three patients were polytraumatized and had open reduction and internal fixation of their hip fracture with external fixation of the femoral shaft fracture, followed later by retrograde intramedullary nailing. 15 patients had isolated femur fractures and 50 patients had other associated injuries. 60 fractures were identified by plain radiograph and CT scan prior to going to the operating room. Two patients had the proximal femur fracture identified in the operating, one in the post anesthesia care unit, and one morbidly obese patient had a basicervical fracture identified in the trauma ICU following retrograde intramedullary nailing. One patient demonstrated a displaced femoral neck fracture after antegrade intramedullary nailing and was converted to screws plus a retrograde intramedullary nail. There were 25 comminuted (OTA 32C), 17 with a butterfly (OTA 32B), 22 transverse (OTA 32A) and 1 distal one-third (OTA 33A) fractures. Two open, comminuted fractures went on to nonunion, one healing after exchange nailing and the other after plating. One patient required dynamization for a shaft delayed union and one required nail removal and antibiotic beads for infection after an open fracture. One patient with a body mass index >40 had thigh pain, no broken hardware, and a lucency that was called a delayed union and was successfully treated with autogenous bone graft. Two patients were nailed 1 cm short. One patient treated for an ipsilateral subtrochanteric fracture with a DCS implant healed in 5° of varus. One patient with a displaced femoral neck fracture developed osteonecrosis. An asymptomatic nonunion of a nondisplaced femoral neck fracture occurred in one patient. One femur was nailed in varus and one femoral neck

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treated with an SHS drifted into varus. 9 patients had knee pain (6 had screw removal), 2 had hip pain, and 1 had hip and knee pain. There was no difference in results when comparing CS to SHS for proximal fractures and the amount of overlap of the retrograde intramedullary nail and the SHS had no influence on union.

**Conclusions:** The treatment of ipsilateral femoral neck fractures with hip screw fixation and a retrograde nail demonstrated good clinical results with 96.7% union for the shaft and 96.7% union for the femoral neck fractures. There was one displacement of a femoral neck fracture and the two delayed unions and one infection of the femoral shaft fractures were successfully treated. There was one predictable case of osteonecrosis after a displaced fracture of the femoral neck. There was no difference in femoral neck union or alignment when comparing CS to an SHS.

**Computerized Navigation for Length and Rotation Control in Femoral Fractures: A Preliminary Clinical Study**

*Yoram A. Weil, MD; Amal Khoury, MD; Alexander Greenberg, MD; Rami Mosheiff, MD; Meir Liebergall, MD;*

*Department of Orthopedics, Hadassah Hebrew University Hospital, Jerusalem, Israel*

**Background/Purpose:** Nailing of femoral fractures is considered to be a very successful procedure with a high healing. However, it is not devoid of complications with malrotation deformity being the most prevailing one. Recent laboratory and cadaver studies have demonstrated the efficacy of computer navigation systems in controlling femoral rotation during femoral shaft fracture fixation. However, clinical data to support these results are still lacking. The aim of the current study is to report and evaluate the clinical results of navigated femoral fracture fixation done on 13 consecutive patients.

**Patients:** This prospective, IRB-approved cohort study was done in an academic Level I trauma center. 13 skeletally mature patients met the inclusion criteria of the study. These included traumatic femoral shaft fracture or fracture malunion/nonunion. Exclusion criteria were ipsilateral femoral neck fracture, existence of a prosthetic joint in either lower extremity, polytrauma precluding prolonged surgery, and extension of the fracture into the knee joint. All surgeries but one were performed by a single surgeon. Ten cases were acute femoral shaft fractures treated with an intramedullary nails. Two patients were treated with plating. For computerized navigation, the BrainLAB Trauma 3.0 Beta version was used as the navigation platform in all cases. A noninvasive optical tracker was placed on the uninjured thigh using a Velcro strap. A handheld tracker placed in the vicinity of a C-arm fluoroscope (X-Spot) was used to track the images along with the noninvasive tracking. The resultant images were marked by the surgeon for the center of the femoral head, the posterior tip of the greater trochanter, the most posterior part of the femoral condyles on a perfect lateral image of the knee, and the center of the knee. The software automatically calculated the axial rotation angle between the proximal and distal femoral landmarks as well as the femoral length. The injured extremity was then prepped and draped in a standard sterile fashion. The femoral nailing procedure was then commenced in a standard surgical fashion. After nail insertion and prior to any nail interlocking, trackers were placed in both proximal and distal injured femur. The identical process of imaging acquisition and landmarking as described above for the uninjured extremity was repeated. At this point, the tracking camera of the navigation system recorded the length and rotation of the injured extremity. The rotation and length were corrected, if possible. Postoperatively, a CT scanogram of both femora was obtained and analyzed twice.

**Results:** Rotational alignment differences as measured by the CT scanogram averaged 5.2° (range, 0-10°) with no case exceeding 10°. The average rotational error obtained during surgery was 2.9° (range, 0-9°). The difference between these two sets of measurements was statistically significant ( $P < 0.01$ ), albeit being small. The average length difference between the two extremities, as measured by the CT, was 7 mm (range, 0-21) as in two cases shortening was observed during surgery and accepted due to comminution. However, the differences between the observed length differences between navigation and CT were not statistically significant.

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**Conclusions:** Use of computerized navigation in femoral shaft fractures has the potential of significantly improving the results of femoral shaft fixation in closed methods in terms of rotational alignment. In none of the cases performed in our study did a clinically significant rotational malalignment occur, including in some severely comminuted fractures.

### Is it Safe to Place a Retrograde Femoral Intramedullary Nail Through a Traumatic Knee Arthrotomy?

Jesse E. Bible, MD; Rishin J. Kadakia, BA; Ankeet A. Choxi, MD;  
Jennifer M. Bauer, MD; **Hassan R. Mir, MD**;  
Vanderbilt Orthopaedic Institute, Nashville, Tennessee, USA

**Purpose:** Retrograde intramedullary nailing of femur fractures in the setting of a traumatic knee arthrotomy (TKA) has been thought by some surgeons to lead to an increased risk of postoperative infection. This stems from the concern of inserting an intramedullary nail through a possibly contaminated knee; however, this belief has never been investigated clinically. The purpose of this study was to analyze the rate of postoperative infection and nonunion following retrograde femoral nail placement in the setting of a traumatic knee arthrotomy with comparison to control groups.

**Methods:** A retrospective review of all adult femur fractures (N = 1748) treated at a single Level I academic center over a 10-year period identified 67 patients (41 retrograde femurs, 26 antegrade femurs) with ipsilateral TKAs. All ballistic injuries and those patients with <6 months of follow-up to union were excluded, leaving 32 retrograde femoral nails with TKA as the study group and 26 antegrade femoral nails with TKA as a control group. Rates of postoperative infection (knee or fracture site) and nonunion were then compared between the retrograde and antegrade groups. Infection was defined as those treated with surgical débridement and irrigation, while nonunion was confirmed with radiographic review or with requirement for surgical revision. The retrograde femoral TKA group was also compared to a 4:1 matched control group of 128 patients with retrograde nails without a TKA. These controls were matched for age, injury (closed/open; if open, Gustilo type), diabetes, and smoking.

**Results:** The TKA groups treated with retrograde and antegrade intramedullary femoral nails did not differ significantly across all recorded variables, including age, diabetes, smoking, injury mechanism, arthrotomy size, and percentage of open fractures ( $P = 0.152-1.000$ ). Four nonunions (12.5%) were identified in the retrograde TKA group versus one nonunion (4.8%) in the antegrade TKA group ( $P = 0.637$ ). Similarly, no infections occurred in the retrograde TKA group versus one infection (4.8%) in the antegrade TKA group ( $P = 0.396$ ). The matched control group of retrograde nails in patients with no TKA had 8 nonunions (6.3%) and 2 infections (1.6%). The rates did not significantly differ when compared to the retrograde TKA group ( $P = 0.260$  and  $0.361$ , respectively).

**Conclusions:** This is the first study to investigate retrograde femoral nail placement through a traumatic knee arthrotomy (TKA) with comparison to 2 control groups (antegrade nails with TKA, retrograde nails without TKA), with no difference found in union rates or infection. Furthermore, there were no postoperative infections in those patients treated with a retrograde nail in the setting of a TKA. This study documents the relative safety associated with retrograde femoral nailing in the setting of a concurrent TKA with appropriate surgical débridement.

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**Posterior Cruciate Ligament Injury With Retrograde Femoral Nailing:  
An Anatomic and MRI Study***Joshua Blomberg, MD; Christopher J. Doro, MD;**Department of Orthopaedics, University of Wisconsin School of Medicine,  
Madison, Wisconsin, USA*

**Purpose:** It has been suggested that retrograde femoral nails can cause posterior cruciate ligament (PCL) injury. The limits of reaming size proposed in the literature suggest a maximum diameter of 13 mm; however, we are unaware of any specific studies or data that support this limit. Our hypothesis is that the PCL will not be damaged to a significant degree with retrograde reaming up to 17 mm, which would be the required diameter for the largest noncustom, commercially available nail.

**Methods:** 20 unmatched embalmed cadaveric knee specimens with soft tissue and skin intact were obtained. The knees were stripped of all soft tissue, except for the knee capsule and ligaments. The distal femurs' AP and lateral diameters were measured with fluoroscopy using a radiographic marker of known diameter. The femurs were then reamed in the standard manner with the Stryker T2 femoral nailing system up to 17 mm in a retrograde fashion with the use of fluoroscopy. Two methods were then used to determine the amount of disrupted PCL. First, the knees were imaged with a 3-T MRI scanner, and sequential measurements were made on the MRI digital images to determine the percentage of disrupted PCL compared to its entire footprint. The second method was photographic quantification. This involved careful dissection of the PCL from its femoral origin after marking the disrupted region. Then NIH Image J software was used to measure the area of marked disrupted PCL fibers. This was quantified as a percentage of the entire femoral origin of the PCL.

**Results:** Evaluation of the 20 specimens using the digital MRI measurement technique showed that a mean of 11.2% (SD 4.8%) of the femoral PCL footprint was disrupted after reaming up to 17 mm. Photographic quantification of the 20 specimens showed a mean of 9.6% (SD 3.7%) of the femoral PCL footprint was disrupted after reaming. Using paired *t* test analysis, the mean difference between the MRI and Image J measurements was found to be 1.6% ( $P = 0.026$ ).

**Conclusions:** Although this was an anatomic study and not a biomechanical or clinical study, the PCL is not significantly disrupted even with very large retrograde femoral reaming. Based on the findings of this study, we feel the distal femur can be reamed up to 17 mm without concern for significant PCL injury. These data could be particularly useful in situations requiring exchange retrograde femoral nailing or in treating osteoporotic femoral shaft fractures when larger nail sizes may be required.

**Femoral Version of the General Population: Does “Normal” Vary by Gender or Ethnicity?**

*John D. Koerner, MD<sup>1</sup>; Neeraj M. Patel, MBS<sup>1</sup>; Richard S. Yoon, MD<sup>2</sup>; Michael S. Sirkin, MD<sup>1</sup>; Mark C. Reilly, MD<sup>1</sup>; Frank A. Liporace, MD<sup>1</sup>;*

*<sup>1</sup>UMDNJ–New Jersey Medical School, Department of Orthopaedic Surgery, Newark, New Jersey, USA;*

*<sup>2</sup>NYU–Hospital for Joint Diseases, Department of Orthopaedic Surgery, New York, New York, USA*

**Purpose:** Baseline femoral version varies between patients and has significant implications for intramedullary (IM) nailing of femoral fractures. Ethnicity and gender may play a role in such variability, but there are little data studying these factors, specifically within the African-American and Hispanic populations. The purpose of this study was to compare various gender and ethnic groups to characterize differences in baseline version and rates of retroversion.

**Methods:** Between 2000 and 2009, 417 consecutive patients with femur fractures were treated with an IM nail at a Level I trauma and tertiary referral center. Of these, 328 with CT scanogram of the normal, uninjured contralateral femur were included in this study. Patients with prior injury or deformity were excluded.

**Results:** The mean alignment for all patients was 8.84° (SD, 9.66°) of anteversion. There were no statistically significant differences in mean version between African-American, Caucasian, and Hispanic patients for males or females. While there were also no significant differences in rates of retroversion between ethnicities, it was found to be common in Caucasian males (21.4%), African-American males (15.1%), and all groups of females (>14.3%). Furthermore, nearly 6% of both African-American males and females exhibited greater than 10° of retroversion.

**Conclusion:** While there may not be a significant difference in average femoral version between ethnic and gender groups, retroversion is relatively common, and retroversion greater than 10° was observed in nearly 6% of the African-American population. This may have important implications in proper alignment restoration and successful clinical outcomes following IM nailing of femur fractures.

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**Entrapped Posteromedial Structures in Pilon Fractures**

*Jonathan G. Eastman, MD; Reza Firoozabadi, MD, MA; Steven K. Benirschke, MD; David P. Barei, MD, FRCSC; Robert P. Dunbar, MD; Harborview Medical Center, Seattle, Washington, USA*

**Purpose:** Our objective was to analyze a series of patients who sustained a pilon fracture and report on the incidence of interposed posterior musculotendinous and neurovascular structures and associated factors.

**Methods:** Through a retrospective review of a prospectively collected trauma database, 394 patients with 420 pilon fractures were identified from January 2005 to November 2011. A senior orthopaedic traumatologist at a regional Level I trauma center treated each patient. Each patient's preoperative CT images were reviewed in detail. The axial, sagittal, and coronal reconstruction CT images were used with both bone and soft-tissue windows to identify the presence of a posterior soft-tissue structure incarcerated within the fracture site. The chart of each patient with an entrapped structure was then thoroughly reviewed to determine the presence of a preoperative neurologic deficit, whether or not a separate posteromedial incision was utilized during the definitive surgery, and whether the final radiology read of the CT imaging commented on the interposed structure.

**Results:** From this cohort, 40 patients (9.5%) had an entrapped posterior soft-tissue structure. The AO/OTA classification showed 13 patients with 43-C3.2 injuries, 11 with 43-C3.3, 5 patients with 43-C2.3, 5 patients with 43-C2.1, 2 patients with 43-C3.1, 2 patients with 43-C2.2, and 2 patients with 43-C1.2 injuries. The CT scans were taken before any surgical intervention in 6 of 40 patients (15%) and were performed after initial spanning external fixation with or without fibular plating in 34 patients (85%). The posterior tibial tendon was interposed in 38 of 40 patients (95%), the flexor digitorum longus tendons in 9 patients (22%), the posteromedial neurovascular bundle in 4 patients (10%), and the flexor hallucis longus in 1 patient. A preoperative neurologic deficit with plantar dysesthesia was present in 5 of 40 patients (12%). A separate posteromedial approach was used in 11 of 40 patients (27%). The final attending radiology read of the CT scan commented on the interposed structure in only 8 of 40 patients (20%).

**Conclusion:** In addition to the osseous injury, CT images can demonstrate nearby and sometimes interposed soft-tissue structures. A careful view of the bone and soft-tissue windows minimizes the chance of missing critical details. In our series, the posterior tibial tendon was most commonly incarcerated but the posterior neurovascular bundle and flexor tendons can also be involved. Entrapment of a posterior structure was most common in more complex articular injury patterns. The possibility of an interposed structure should not be overlooked in more simple injuries. Proper preoperative planning can confirm a physical examination, plan and allow for structure extraction, and ensure proper reduction and internal fixation. In some cases, this may not be possible through common anterior surgical intervals and a separate posteromedial approach may be required. Failure to recognize the presence of an interposed structure could lead to a malreduction, impaired tendon function, neurovascular insult, and the need for further surgery. Pilon fractures are complex injuries and taking account of all involved factors will help achieve the optimal surgical, functional, and clinical outcomes in these difficult injuries.

See pages 97 - 144 for financial disclosure information.



**Posterior Bone Loss as a Surrogate for Articular Injury in Supination External Rotation (SER) Ankle Fractures**

*Milton T.M. Little, MD; Marschall B. Berkes, MD; Lionel E. Lazaro, MD; Peter K. Sculco, MD; Rachel M. Cymerman, BA; Nadine C. Pardee, BS; David L. Helfet, MD; Dean G. Lorich, MD; Hospital for Special Surgery/New York Presbyterian Hospital-Cornell, New York, New York, USA*

**Purpose:** Postoperative CT scans of supination external rotation (SER) IV ankle fractures treated with open reduction and internal fixation at our institution has revealed a collection of patients with posterior bone loss despite an otherwise anatomic reduction. We hypothesize that this radiographic finding is a surrogate marker for significant articular damage and a risk factor for poor clinical outcomes. The purpose of this investigation was to compare outcomes between those patients with and those without evidence of posterior bone loss.

**Methods:** 108 SER IV/equivalent ankle fractures fulfilled inclusion criteria consisting of 1 year of clinical follow-up, preoperative radiographs, postoperative radiographs, and Foot and Ankle Outcome Scores (FAOS). Preoperative MRI was performed for all patients to evaluate ligamentous injury and immediate postoperative CT scans were performed to assess posterior bone loss ( $\geq 2$  mm of articular bone loss), reduction ( $< 2$  mm of articular stepoff), and syndesmotomic reduction. The primary outcome evaluated was FAOS. The secondary outcomes included range of motion and postoperative complications. Outcomes were compared between those fractures with or without evidence of posterior bone loss.

**Results:** 29 patients (27%) had  $\geq 2$  mm of posterior bone loss on CT scan. There was no significant difference in the rate of articular reduction, syndesmotomic reduction, range of motion, or postoperative complications between groups. Posterior bone loss was associated with significantly worse functional outcomes in the FAOS subgroups of symptoms (65.8 vs 76.8,  $P = 0.012$ ) and pain (72.7 vs 83.3,  $P = 0.011$ ).

**Conclusions:** Posterior bone loss diagnosed by postoperative CT scan is associated with worse functional outcomes in certain subcategories of the FAOS outcome score despite anatomic fracture reduction. This radiographic finding may serve as a surrogate marker for higher-energy articular impaction injuries and articular damage.

- The FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an "off label" use). For full information, refer to page 619.

**Intramedullary Nailing of AO/OTA Type 43C Distal Tibia Fractures***Matthew S. Marcus, MD<sup>1</sup>; Frank A. Liporace, MD<sup>2</sup>; Richard S. Yoon, MD<sup>3</sup>;**Kenneth J. Koval, MD<sup>4</sup>; George Haidukewych, DO<sup>4</sup>; Joshua Langford, MD<sup>4</sup>;**<sup>1</sup>Jersey City, New Jersey, USA;**<sup>2</sup>UMJNJ, Newark, New Jersey, USA;**<sup>3</sup>NYU Hospital for Joint Diseases, New York, New York, USA**<sup>4</sup>Orlando Health, Orlando, Florida, USA*

**Background/Purpose:** Open reduction and internal fixation (ORIF) is frequently considered definitive treatment for AO/OTA Type 43C distal tibia fractures, with intramedullary nailing (IMN) used mainly for salvage and fusion procedures. To our knowledge, there has been no literature about the use of IMN for the treatment of simple distal tibia articular fractures with associated metadiaphyseal components. With noted similarities between extra-articular distal tibial fracture (AO/OTA Type 43A) and simple pilon fracture (AO/OTA Type 43C) patterns, IMN has been utilized at the Level I trauma centers included in this multicenter review. The purpose of this retrospective study is to share our experience, contending that IMN can be readily utilized for articular fractures of the tibial plafond while maintaining good alignment, high union rates, and minimal complications.

**Methods:** IRB approval was received prior to the collection of data. Patients from 5 orthopaedic trauma fellowship-trained surgeons at two Level I trauma centers were reviewed from December 2004 to March 2010. 25 patients were identified to have at least 1 year of clinical follow-up with an AO/OTA Type 43C distal tibia fracture. All fractures were stabilized definitively in the same surgical setting. Tibial alignment measurements in both frontal (varus/valgus) and sagittal (anterior/posterior) planes were performed by two fellowship-trained orthopaedic traumatologists at two time points: immediately postoperative and at time of union. Malreduction was considered  $>5.0^\circ$  in the metadiaphyseal region, any plane on radiograph, or articular incongruity of  $>1$  mm. Union was defined as healing on at least three cortices without bony tenderness on palpation and pain free ankle motion. The majority of our patients suffered AO/OTA Type 43 C1 fractures (72%), followed by Type 43 C2 (24%) and Type 43 C3 (4%) fractures. Four (16%) had an open fracture. All 25 (100%) patients received a tibia intramedullary nail; 1 case had a provisional supplemental plate as a reduction tool. 22 patients (88%) received independent screw fixation, separate from the IMN, of the articular injury. 13 patients (52%) received suprapatellar nails in semiextended position, while 12 patients (48%) received medial parapatellar nails in supine position. 17 (68%) had ORIF of a distal fibular fracture. One patient had a temporizing spanning external fixator prior to definitive fixation.

**Results:** All patients achieved clinical and radiographic union with a mean time of  $14.8 \pm 4.9$  weeks. Mean frontal plane alignment was  $1.2 \pm 1.6^\circ$  valgus immediately postoperatively with no significant change by final follow-up ( $P = 0.75$ ). Mean alignment in the sagittal plane did not significantly change from the immediate postoperative period (mean  $1.2^\circ$  apex posterior) by final follow-up ( $P = 0.59$ ). There were one superficial and two deep infections.

**Conclusions:** IMN is a reasonable treatment option for lower-grade AO/OTA Type 43C fractures, with the ability to achieve anatomic reduction with low complication rates. However, experienced hands may be necessary to reproduce our excellent results. Prospective, randomized trials along with longer-term follow-up are necessary in order to definitively assess the efficacy of this treatment method for this particular fracture pattern.

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**Surgical Treatment of Nonunion Following Rotational Ankle Fractures**

*Sonya Khurana, BS; Raj Karia, MPH; Jordanna M. Forman, BS; Kenneth A. Egol, MD; NYU Hospital for Joint Diseases, New York, New York, USA*

**Purpose:** There have been few studies published in the literature about nonunions of rotationally induced ankle fractures. The purpose of this study is to evaluate the incidence, treatment, and outcomes following surgical treatment of ununited rotational ankle fractures.

**Methods:** Over a 5-year period, 251 patients who presented with a fracture nonunion at a single institution were followed in a prospective database. Of these, 17 patients (6.8%) were identified as having a nonunion of a rotational ankle fracture involving either the medial malleolus or distal fibula. All patients were evaluated clinically and radiographically. All patients were evaluated functionally with the Short Musculoskeletal Function Assessment questionnaire (SMFA) and were compared to the SMFA scores of 55 patients who had normal healing following a nonoperative (supination-external rotation [SE]2) ankle fracture and 28 patients who had normal healing after surgical fixation of their SE4 ankle fracture. Statistical analysis was performed using the Student *t* test and Pearson  $\chi^2$  test.

**Results:** 3 of the 17 patients were excluded from analysis. Of the remaining 14 patients, there were 5 males and 9 females with an average age of 47.4 years (range, 23-75). They did not differ in age or gender from the other two groups of patients. The average body mass index of the patients with nonunion was 29.8. Sites included 12 distal fibula (93%) and 2 medial malleolus. Nine patients had previous surgeries and five were treated nonoperatively before developing a nonunion. 12 patients (86%) were treated with open reduction with plate and screw fixation and grafting. No patients in group A were lost to follow-up. The average time to healing was 4.9 months postsurgery (range, 3-10.5). At latest follow-up (mean 33.6 months [range, 4-86]), all nonunions had healed. The SE2 patients had a significantly greater range of plantar flexion compared with the nonunion patients. There was no difference in range of motion between the SE4 and nonunion patients. SMFA scores in the nonunion patients were comparable with those of the SE2 group in the functional category (15.0 vs 9.3,  $P = 0.09$ ), but were worse in the bothersome (16.7 vs 4.6,  $P < 0.01$ ), mobility (20.8 vs 6.8,  $P < 0.01$ ), daily activities (17.9 vs 6.8,  $P < 0.04$ ), and emotional (17.6 vs 4.14,  $P < 0.001$ ) categories. There was no difference in SMFA scores between the nonunion and surgically treated SE4 patients' group, however.

**Conclusions:** Nonunions of fractures about the ankle are quite rare. This series is the largest to date reporting outcomes of patients with these injuries. Surgical treatment of nonunions about the ankle leads to exceptional healing rates. Patients who undergo surgery for nonunion of ankle fractures do not fare as well as patients who sustain simple ankle fractures, but ultimately have similar functional outcome scores compared with those patients who had undergone surgical treatment for more a complex, acute ankle fracture.

**Do Foot Fasciotomies Really Prevent Neuropathic Pain and Deformity?**

*CPT Katherine M. Bedigrew, MD; CPT Daniel J. Stinner, MD; COL John F. Kragh, Jr., MD; MAJ Benjamin K. Potter, MD; LTC Scott B. Shawen, MD; LTC Joseph R. Hsu, MD, LTC, MC; Skeletal Trauma Research Consortium (STRcC); San Antonio Military Medical Center, Fort Sam Houston, Texas, USA; Walter Reed Army Medical Center, Washington, District of Columbia, USA*

**Purpose:** Foot compartment syndrome has been reported to cause neuropathic pain, claw or hammer toes, and motor and sensory disturbances. It is unclear whether foot fasciotomies change these outcomes. The purpose of this study is to determine if foot fasciotomies improve patient outcomes in those who sustained high-energy lower extremity trauma during the current conflicts in Afghanistan and Iraq.

**Methods:** The U.S. military Joint Theater Trauma Registry was searched from May 2007 to January 2009 using ICD-9 codes related to compartment syndrome. Medical records were retrospectively reviewed to identify patients with foot compartment syndrome. Matched control patients were identified from a surgical database based on similar hindfoot, midfoot, and/or forefoot fractures during a similar time period. Primary outcome measures compared were: the development of claw or hammer toes, neuropathic pain, motor or sensory deficits, or stiffness during their treatment course.

**Results:** Of the identified 268 patients with compartment syndrome, 19 occurred in the foot. Median follow-up was 19.5 months (range, 3.5-47.5 months). 18 of 19 patients underwent early fasciotomy, 3 of the 18 early fasciotomies were revised, and 1 of 19 underwent a delayed fasciotomy. The most common mechanism of injury was an explosion (fasciotomy 84%, control 89%;  $P = 0.50$ ). Eight fasciotomy and nine control patients sustained open foot fractures. Significantly more patients who underwent foot fasciotomies for compartment syndrome developed claw toes (50% vs 16.6%,  $P = 0.034$ ) and motor deficits (52.6% vs 15.8%,  $P = 0.0167$ ). There were no significant differences in development of neuropathic pain (73.7% vs 52.3%,  $P = 0.18$ ), sensory deficits (77.8% vs 63.2%,  $P = 0.33$ ), or stiffness (68.4% vs 89.5%,  $P = 0.23$ ). Four patients in each group ultimately underwent lower extremity amputation.

**Conclusion:** Surgical decompression of compartment syndrome of the foot did not prevent neuropathic pain and deformities in this study. Although limited by its retrospective nature, this study suggests there may be enough clinical equipoise in the management of foot compartment syndrome to warrant a randomized clinical trial.

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### **Sustentaculum Screw Placement During Calcaneal Open Reduction and Internal Fixation: When Is the Screw Out?**

*Ida L. Gitajn, MD; R. James Toussaint, MD; John Y. Kwon, MD;  
Massachusetts General Hospital, Boston, Massachusetts, USA*

**Background/Purpose:** During fixation of calcaneal fractures a screw is often placed from lateral to medial into the sustentaculum as the constant fragment. This can be technically difficult as the sustentaculum is a small anatomic structure and this screw is generally placed from lateral to medial under fluoroscopic guidance using the axial Harris calcaneal heel view. Misplacement of this screw can result in significant complications given the high density of functionally important structures in this anatomic area, including the flexor digitorum longus, flexor hallucis longus, subtalar joint, tarsal canal, and neurovascular structures. Therefore the aims of this study were to determine whether there are certain fluoroscopic axial heel views taken at specific angles that can accurately confirm correct placement or misplacement of the sustentacular screw.

**Methods:** Lateral and medial dissection was performed on one cadaver foot specimen to remove skin and subcutaneous tissues. A 4.0-mm cancellous screw was placed from lateral to medial in five different configurations: (1) screw placed anatomically within the sustentaculum, (2) screw misdirected inferior to the sustentaculum, (3) screw misdirected superior to the sustentaculum, (4) screw misdirected anterior to the sustentaculum, and (5) screw misdirected posterior to the sustentaculum. A large C-arm was used to obtain Harris heel views at five different angulations (10°-50°). Two orthopaedic residents and one orthopaedic attending analyzed the C-arm images to determine at which angulation the screw placement could be confirmed in each cadaver.

**Results:** A screw placed anatomically was noted to be radiographically within the sustentaculum in all five views (Harris heel view at 10°, 20°, 30°, 40°, and 50°). An inferiorly misdirected screw appeared to be radiographically within the sustentaculum at 30°, 40°, and 50° but was confirmed to be misplaced inferiorly on the 10° and 20° views. A posteriorly misdirected screw was confirmed to be misplaced posteriorly on all five views (10°, 20°, 30°, 40°, and 50° Harris heel views). An anteriorly misdirected screw appeared to be radiographically within the sustentaculum on the 10° view but was confirmed to be misplaced anteriorly on all other views (20°, 30°, 40°, and 50° views). A superiorly misdirected screw was confirmed to be misplaced on all views (10°, 20°, 30°, 40°, and 50° Harris heel views). Interobserver agreement on placement of the sustentacular screw was 100% among all three authors.

**Conclusion:** Clinicians should be aware that in order to verify correct placement of the sustentacular screw several axial Harris heel views are required. Axial heel views must be obtained at 10° to 20° to assess for inferior misplacement of the screw and views must be obtained at 20° to 50° to evaluate for anterior misplacement of the screw.

### **Predictive Factors of Hospital Length of Stay in Patients With Surgically Treated Ankle Fractures**

*Matthew R. McDonald, BS; Jesse Ehrenfeld, MD, MPH; Khensani Marolen, MPH; A. Alex Jahangir, MD; William T. Obremsky, MD, MPH; Manish K. Sethi, MD; Vanderbilt University Medical Center, Nashville, Tennessee, USA*

**Background/Purpose:** Surgical fixation of ankle fractures is common. However, as reimbursement plans evolve with the potential of a bundled payment model, it is critical that orthopaedic trauma surgeons better understand factors influencing the postoperative length of stay (LOS) in patients undergoing surgical fixation of ankle fractures to negotiate appropriate reimbursement. Our purpose was to identify factors influencing the postoperative LOS in patients with surgically treated ankle fractures.

**Methods:** 622 patients with isolated ankle fractures were identified between January 1, 2004 and December 31, 2010. These patients' charts were reviewed for gender, body mass index, length of operative procedure, method of fixation, American Society of Anesthesiologists Physical Status (ASA) classification, medical comorbidities, and postoperative LOS. Analysis of the variance was conducted to determine significant trends. Financial data for an average 24-hour inpatient stay were obtained from financial services.

**Results:** 622 patients were included in this retrospective review. In a linear regression analysis, a statistically significant relationship was demonstrated between ASA status and length of stay ( $P < 0.001$ ). Multiple regression analysis was conducted to further characterize the relationship between ASA classification and LOS: a 1-unit increase in the ASA classification conferred a 3.49-day increase in LOS on average ( $P < 0.001$ ). Based on an average per day inpatient cost of \$4503, each unit increase in ASA status led to an \$18,800 increase in cost to the institution.

**Conclusions:** Our study demonstrates that ASA status is a powerful predictor of LOS in patients undergoing surgical fixation of ankle fractures. Furthermore, this demonstrates a need for additional study to uncover the factors driving this variation in LOS among postoperative ankle fracture patients. An understanding of these factors will lead to better risk adjustment models for measuring outcomes, determining fair reimbursement, and potential improvements to the efficiency and timeliness of these patients' care.

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### Return to Duty of Special Operations Command Personnel After Limb Salvage for High-Energy Lower Extremity Trauma

*Jeanne Cameron Patzkowski, MD, CPT, MC, USA; Johnny G. Owens, MPT;*

*Ryan V. Blanck, LCPO; Joseph R. Hsu, MD, LTC, MC;*

*Skeletal Trauma Research Consortium (STReC);*

*San Antonio Military Medical Center, Fort Sam Houston, Texas, USA*

**Purpose:** High-energy lower extremity trauma (HELET) is common in modern warfare. Damage to the lower extremities is often severe, incorporating massive soft-tissue injury, chronic pain, neurovascular injury, and volumetric muscle loss. We sought to determine the characteristics and outcomes of active duty service members assigned to the Special Operations Command (SOCOM) who have sustained HELET and completed the Return to Run clinical pathway.

**Methods:** At our facility we have instituted a novel rehabilitation and orthotic initiative, the Return to Run (RTR) clinical pathway, designed to facilitate the return to duty of these high-functioning service-members. The RTR incorporates a custom energy storage and return ankle-foot orthosis, the Intrepid Dynamic Exoskeletal Orthosis, and a high-intensity sports medicine-based rehabilitation program. The RTR database was queried for individuals enrolled in the RTR and members of the SOCOM. Medical records were reviewed for demographic, injury, and surgical data. Functional, occupational, and recreational capabilities were determined from outpatient records. Functional capabilities include the ability to walk without assistive devices, ability to run, and ability to jump. Occupational capabilities include the ability to stand continuously for greater than 1 hour, move with a load greater than 20 lb, ability to return to duty in the SOCOM, and deployment to combat in the SOCOM. Recreational capabilities include recreational running and agility sports participation.

**Results:** At the time of this review 14 SOCOM service members were identified who had completed the RTR. An additional 9 were actively participating in the RTR, but were not included in this analysis. 10 subjects were members of the Army Special Forces, 3 were Navy Sea Air Land (SEALs), and 1 an Air Force Pararescue Jumper (PJ). All 14 sustained injuries due to HELET. One patient developed chronic tibia osteomyelitis after bilateral pilon fractures and eventually underwent transtibial amputation. Three others initially considered amputation of their injured limb, but have countermanded their request since enrolling in the RTR. With the exception of the patient who underwent amputation, all subjects are able to ambulate without assistive devices, run, jump, have returned to duty, stand for prolonged periods, move with a load, and participate in recreational running and agility sports. Seven have deployed to combat with the SOCOM or are in predeployment training since completion of the RTR.

**Conclusion:** Using the RTR, 13 of 14 service-members have returned to duty, and 7 have deployed to combat with the SOCOM after sustaining severe high-energy lower extremity trauma.



**Three-Dimensional, Digital, and Gross Anatomy of the Lisfranc Ligament***Vinod K. Panchbhavi, MD; Domingo Molina IV, BS; Jaime Villarreal, BS;**Michael C. Curry, MD; Clark R. Andersen, MS;**Department of Orthopaedic Surgery and Rehabilitation, University of Texas Medical Branch, Galveston, Texas, USA*

**Purpose:** There are inconsistencies in the descriptive anatomy of the Lisfranc ligament. No information is available on the orientation of fibers or presence of bundles, nor are there three-dimensional anatomic data on the ligaments or their attachments. This study assessed the three-dimensional anatomy of the Lisfranc ligament and its attachment sites.

**Methods:** 37 cadaver feet were dissected to expose the ligament attachments at the Lisfranc joint. The Lisfranc and plantar attachments were outlined and then removed with the attachment outlines preserved. A three-dimensional digitizer was used to digitize bony and articular surfaces, as well as ligament attachment sites, at approximately 1-mm intervals; the positional accuracy was 0.23 mm. The surface areas of the entire bone, articular regions, and Lisfranc and plantar ligament attachment regions were determined and anatomic details were noted.

**Results:** The Lisfranc ligament had a single bundle in 73% of the specimens (27 of 37) and two bundles in 27% (10 of 37). Both variations had a single attachment to the second metatarsal (M2; mean attachment surface area, 135 mm<sup>2</sup>). The single-bundle variation attached to the medial cuneiform (C1; mean attachment surface area, 140 mm<sup>2</sup>). The plantar ligament, C1-M2-M3, attached to the anterior plantar surface of the lateral aspect of C1 (mean attachment surface, 64 mm<sup>2</sup>) and had attachment sites at the bases of M2 and M3. Its fibers ran anteriorly and inferiorly, with attachments to the proximal inferomedial aspect of M2 (mean attachment surface, 63 mm<sup>2</sup>) and fibers extending to a smaller attachment at the plantar aspect of M3 (mean attachment surface area, 26 mm<sup>2</sup>).

**Conclusion:** The Lisfranc ligament is variable in anatomy and can have a single- or double-bundle arrangement. Its area of attachment is larger than that of the plantar ligament. Anatomic description of the location, dimensions, and variability in position and surface area of the ligament attachment sites and of orientation of the bundles provides information for future attempts at repair or reconstruction of the Lisfranc ligament.

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### Accuracy and Reliability of Bohler's Angle Measurements With Oblique Lateral Radiographs Taken in the Trauma Setting

R. James Toussaint, MD; Ida L. Gitajn, MD; John Y. Kwon, MD;  
Massachusetts General Hospital, Boston, Massachusetts, USA

**Background/Purpose:** First described in 1931, Bohler's angle is used to determine the amount of posterior facet displacement and severity of injury in calcaneus fractures. It is used to guide management or the need for additional imaging. Lateral images used to obtain Bohler's angle in the trauma setting are often oblique due to difficulties in positioning of the traumatized extremity or limitations from splint materials. Inaccurate Bohler's angles in this setting can lead to under/overtreatment of patients. The purpose of this study is to assess the accuracy and reliability of measuring Bohler's angle on oblique lateral imaging and to determine how improper imaging influences measurement.

**Methods:** A cadaver specimen was imaged using a large C-arm to obtain multiple fluoroscopic images. First, a perfect lateral was obtained. Next, a series of oblique images was taken with the beam directed anteriorly, posteriorly, cephalad, and caudad. The images were taken in 5° increments from 5° to 25° in each direction. Orthopaedic staff and residents were asked to measure the observed Bohler's angles. To define the true Bohler's angles, metallic markers were then placed on the anterior calcaneal process, the superior most portion of the posterior facet, and the superior posterior tuberosity of the same cadaver calcaneus. The same series of images were repeated to measure true Bohler's angles using the marked specimen. The senior author then measured the true Bohler's angles from the marked specimen.

**Results:** 41 orthopaedic staff and residents participated in the study. The mean values for the observed Bohler's angles were significantly different ( $P < 0.05$ ) from the true Bohler's angles for all series of images except a posteriorly directed x-ray beam at 20° from the horizontal ( $P = 0.43$ ). The mean value for observed Bohler's angles deviated further from the true Bohler's angles with increasing image obliquity for all series except the posteriorly directed x-ray beam. The true Bohler's angle on a perfect lateral image was 35°. The true Bohler's angle was found to vary based on the obliquity of the fluoroscopic image (see table below)

**Table** Changes in true Bohler's angles with oblique fluoroscopic images

Fluoro Direction (5°-25°)	True Bohler's Angle Range, degrees	Fluoro Direction (5°-25°)	True Bohler's Angle Range, degrees
Anteriorly	36-40	Cephalad	24-34
Posteriorly	34-37	Caudad	37-39

**Conclusion:** The study findings reveal that orthopaedic staff and resident physicians' ability to accurately measure Bohler's angle significantly decreases with increasing obliquity of lateral radiographs. The true Bohler's angle also varies with image obliquity. Understanding these changes with oblique lateral radiographs taken in the trauma setting should decrease reliance on only Bohler's angle to determine management and need for additional imaging.

See pages 97 - 144 for financial disclosure information.

**Peroneal Tendon Dislocation Associated With Intra-Articular Calcaneus Fractures: An Underappreciated Problem**

R. James Toussaint, MD<sup>1</sup>; Darius Lin, MD<sup>1</sup>; Lauren K. Ehrlichman, MD<sup>1</sup>;  
Seenu Susarla, MD, DMD<sup>1</sup>; J. Kent Ellington, MD, MS<sup>2</sup>; Nicholas Strasser, MD<sup>2</sup>;  
John Y. Kwon, MD<sup>1</sup>;

<sup>1</sup>Massachusetts General Hospital, Boston, Massachusetts, USA;

<sup>2</sup>Carolinas Medical Center, Charlotte, North Carolina, USA

**Background/Purpose:** Peroneal tendon dislocations (PTDs) are often undetected and undertreated complications of intra-articular calcaneus fractures. Existing studies demonstrate an association of PTD with intra-articular calcaneus fractures using CT. However, these studies are limited by small sample sizes, making the determination of true incidence unreliable. Further, existing research does not correlate fracture classification with PTD and therefore offers little prognostic value. The goals of this multicenter, retrospective study are to determine: (1) incidence of PTD associated with intra-articular calcaneus fractures, (2) correlation of PTD with fracture classification, (3) association of PTD and heel width, and (4) the rate of missed radiographic diagnosis and subsequent lack of treatment of PTD.

**Methods:** An IRB-approved review of calcaneus fractures from June 30, 2006 to June 30, 2011 was performed. Cases of intra-articular calcaneus fractures on plain film and CT imaging were included. Fractures were classified by the Essex-Lopresti and Sanders classifications. CT imaging was used to measure heel width and to identify PTD using available techniques. Plain radiographs were examined for signs of PTD (ie, “fleck” sign, distal fibular avulsion fracture). Radiology reports were reviewed for identification of PTD. Medical records of PTD cases were reviewed for operative treatment of PTD at initial fracture fixation or at a later date.

**Results:** Of 354 calcaneus fractures, 269 (76%) were intra-articular. 63.2% were classified as joint depression, the remainder were tongue type. 13.8% were Sanders I, 37.1% Sanders II, 27.5% Sanders III, and 17.1% were Sanders IV. 31.7% of intra-articular fractures had peroneal tendon dislocations. There was a statistically significant correlation between heel width ( $P < 0.001$ ) and joint depression fractures ( $P = 0.003$ ) with PTD. Sanders IV fractures were statistically significant and more likely to have PTD than Sanders Class I to III fractures ( $P = 0.003$ ). Radiologists identified 9.2% of PTDs on CT scans. None (0%) of the fractures with PTD taken for surgical fixation had the peroneal tendons surgically addressed. The “fleck” sign was seen in 5.6% of patients with PTD. This diagnostic test for PTD had a sensitivity of 21%, a specificity of 100%, a positive predictive value of 100%, and a negative predictive value of 73%.

**Conclusions:** The results of our study demonstrate a statistically significant and high incidence of PTD with intra-articular calcaneus fractures. This injury is often overlooked by radiologists and undertreated by orthopedists. Further research is required to determine if this finding is linked with increased patient morbidity.

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### Functional Outcomes of Supination External Rotation Type IV Ankle Fracture-Dislocations

Peter K. Sculco, MD; Lionel E. Lazaro, MD; Milton M.T. Little, MD; Marschall B. Berkes, MD; David L. Helfet, MD; Dean G. Lorich, MD; Hospital for Special Surgery, New York, New York, USA

**Background/Purpose:** An ankle fracture-dislocation represents a traumatic injury with significant disruption of soft tissue and osseous restraints along with a high likelihood of chondral injury. Supination external rotation type IV (SER IV) injuries are the most common operative fracture pattern of the Lauge-Hansen classification. The purpose of this study is to identify demographic risk factors for ankle fracture-dislocation and to compare subjective and objective clinical outcomes of SER IV ankle fracture-dislocations to a matched cohort of SER IV ankle fractures without dislocation.

**Methods:** From 2004 through 2010, all operative SER IV ankle fractures treated by a single surgeon were enrolled in a prospective database. All patients with SER IV ankle fractures were identified and demographic and medical comorbidities were collected. Preoperative radiographs and MRI were performed to characterize the injury and assist preoperative planning. For comparison, Group 1 consisted of ankle fracture with dislocation and Group 2 enlisted all ankle fractures without dislocation. Postoperative CT was used to assess reduction. Patients with at least 1 year of clinical follow-up were analyzed in a retrospective analysis. The primary and secondary outcome measures were the Foot and Ankle Outcome Score (FAOS) and ankle and subtalar range of motion (ROM).

**Results:** Included in this analysis were 108 patients with SER IV type fractures with a mean age of 51 years. Group 1 (fracture-dislocation) had 49 patients (45%) and Group 2 (without dislocation) had 59 patients (55%). Four patients had open ankle fracture-dislocations. Tri-malleolar ankle fractures had the highest rate of dislocation of all SER IV subtypes with 24 of 49 (49%). Patient demographics and comorbidities were similar between groups. There was a higher rate of external fixation in the fracture-dislocation group ( $P < 0.001$ ). At a mean follow-up of 21 months, ankle fracture-dislocations had increased pain on FAOS outcome measures. Ankle-fracture dislocations also had worse ankle tibiotalar and subtalar ROM in all planes of motion with significant loss of plantar flexion ( $P < 0.001$ ) compared to non-dislocated equivalents.

**Conclusion:** In this series of SER IV ankle fractures, ankle fracture-dislocations had a higher rate of external fixation, increased pain, and decreased ankle and subtalar ROM. The accuracy of the articular reduction and restoration of the syndesmosis was similar between groups. These results suggest that the initial soft-tissue injury in a dislocation contributes to the persistent pain and functional loss in patients with a fracture-dislocation, regardless of the accuracy of the articular fixation. This information may be helpful to the treating physician in counseling patients regarding clinical outcomes after ankle-fracture dislocation.

**CT Analysis of Medial Cuneiform Density**

*Nick Boutris, BS; Karan A. Patel, BS; Domingo Molina, IV; Clark R. Andersen, BS; Vinod K. Panchbhavi, MD; University of Texas–Medical Branch, Galveston, Texas, USA*

**Background/Purpose:** A cannulated lag screw inserted from the medial cuneiform bone into the base of the second metatarsal is utilized to reduce and hold the diastasis and to aid in the healing of a Lisfranc ligament injury. The medial cuneiform is a cancellous bone of variable density. We used CT to identify the densest part of the medial cuneiform through the use of Hounsfield units (HU). Our findings may help determine where screw placement would yield the best purchase possible.

**Methods:** In 60 randomly selected healthy subjects, mean CT intensity in HU was determined at 12 sampled locations within the medial cuneiform. A study by Spruit et al demonstrated that increasing bone mineral content was correlated with an increase in HU. Regardless of foot, the first point (A1, M1, P1) was always the dorsal-lateral region. Analysis of variance (ANOVA) was used to assess the effect of age, gender, race, and sample site on bone density, using CT intensity as a proxy for bone density. Statistical testing assumed a 95% confidence level, and a Tukey-Kramer adjustment for multiple comparisons was used in pairwise comparisons.

**Results:** ANOVA showed that age, gender, and location within the medial cuneiform all had a statistically significant effect ( $P < 0.001$ ) on bone density. No significant effect was found for race ( $P = 0.28$ ). The anterior-dorsal-lateral site was significantly denser than all other sites ( $P < 0.001$ ) except the middle-dorsal-lateral ( $P = 0.53$ ). The posterior-plantar-lateral site was significantly less dense than all other sites ( $P < 0.001$ ) except the middle-plantar-lateral/medial and the posterior-plantar-medial sites ( $P < 0.14$ ). A general trend of increasing density in the anterior and dorsal directions was evident, and within the dorsal sites there was a trend of increasing density in the lateral direction.

**Discussion/Conclusion:** This is the first study to assess density of the medial cuneiform in living subjects. A study by Pelt et al analyzed the density of the medial wall of the medial cuneiform in cadaveric bone. Another study by Coskun et al analyzed only the articulating surface of the medial cuneiform in the tarsometatarsal joint using cadaveric specimens. Our study had a larger sample size and enrolled healthy subjects as opposed to using cadaveric feet. As in the Pelt study, we found the most distal portion of the medial wall to have the highest density. However, we found no significant difference in the dorsal versus the plantar regions of the cuneiform. We conclude that the most anterior, dorsal, and lateral portion of the medial cuneiform is the densest.

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### The Role of Preoperative CT Scans in Operative Planning and Fixation of Malleolar Ankle Fractures

*E. M. Black; V. Antoci; J. T. Lee; M. J. Weaver; A. H. Johnson; S. M. Susarla; John Y. Kwon; Massachusetts General Hospital and Brigham and Women's Hospital, Boston, Massachusetts, USA*

**Purpose:** The purpose of this study was to determine the role of preoperative CT scans on surgical planning in malleolar ankle fractures. We hypothesized that CT would play an increasing role in surgical planning with fractures of higher energy and with lesser-quality preoperative radiographs.

**Methods:** A retrospective analysis was performed on the records of 100 consecutive patients treated at our institution between 2006 and 2010 for malleolar ankle fractures (AO Type 44) who had both preoperative radiographs as well as CT scans. Three fellowship-trained orthopaedic attending surgeons and three orthopaedic residents reviewed available preoperative radiographs and formulated an operative (or nonoperative) plan including patient positioning, surgical approach, and fixation methods for all applicable components of the fracture. The six reviewers then analyzed CT scans of the same fractures and decided whether or not and how they would alter their operative strategy based on the CT scan. Fracture characteristics including number of involved malleoli, AO classification, quality and nature of preoperative radiographs, and presence of dislocation on hospital presentation were noted and correlated with changes in operative strategy.

**Results:** Operative strategy was significantly changed in 24% of cases after review of the CT scan. There was strong intraclass correlation between all reviewers (0.733), and no significant difference based on level of training ( $P = 0.57$ ). The most common changes in operative strategy involved fixation of the medial malleolus (21%), posterior malleolus (15%), and fixation of an occult anterolateral plafond fracture (9%). Predictors of changes in operative strategy included trimalleolar over unimalleolar fractures (29% vs 10% rate of change), preoperative dislocation over no dislocation (31% vs 20%), the presence of only radiographs with overlying plaster versus fractures with at least one set of radiographs without plaster (25% vs 14%), and suprasyndesmotic fractures vs. trans- and infrasyn-desmotic fractures (40% vs 20% and 4%, respectively).

**Conclusions:** CT scans may be useful adjuncts in preoperative planning for malleolar ankle fractures, most notably in fracture dislocations, poor-quality preoperative radiographs, trimalleolar fracture patterns, and suprasyndesmotic (AO 44-C) ankle fractures.

### **Pie-Crusting Reduces Skin Tension During Suture Closure of Open Wounds: A Cadaveric Animal Study**

*Gregory J. Della Rocca, MD, PhD, FACS; Adam C. Crawford, MD; Tyler A. Dailey, BS; Brett D. Crist, MD; James P. Stannard, MD; David A. Volgas, MD; Ferris M. Pfeiffer, PhD; University of Missouri, Columbia, Missouri, USA*

**Purpose:** Multiple small relaxing skin incisions (so-called “pie crusting”) near traumatic lacerations or surgical incisions have been used to achieve primary closure when edema or skin loss would otherwise preclude it. We elected to undertake a biomechanical analysis of the pie-crusting method in order to investigate the effectiveness of pie-crusting for reducing tension after suture closure of wounds.

**Methods:** 16 fresh cadaveric porcine limbs were collected from animals euthanized for reasons unrelated to the study. A 60-mm elliptical incision with a 1-cm maximal width was made on each leg through the epidermis and dermis. The distal and proximal sections of each specimen were fixed to the table of an Instron test machine using clamps and a custom fixture. One suture (0 prolene) was passed through the skin at the midpoint of the ellipse, with one end of the suture held rigidly to the table using a clamp and the other end of the suture held in a gripper attached to the Instron ram. The Instron ram was raised in displacement control at a rate of 0.1 mm/sec until the suture gap was closed. The maximum load required to approximate the midportion of the ellipse was recorded for each sample prior to pie-crusting. Next, the Instron ram was lowered and a line of three “pie-crust” incisions (each 5 mm in length and 1 cm separated from each other) were made on either side of the ellipse, at approximately 1 cm from the ellipse. Subsequently, the Instron ram was raised until the suture gap was closed, and the maximum ellipse closure force was recorded. Finally, the Instron ram was lowered and a second parallel line of relief pie-crust incisions were made 1 cm further from each of the first pie-crust lines. The Instron ram was again raised until the suture gap was closed, and the maximal closure force was recorded. Data were analyzed using a paired, two-tailed Student *t* test with reverse Bonferroni correction for multiple mean comparisons.

**Results:** Prior to pie-crusting, the average force required to close the midportion of each ellipse was 18.49 N (95% confidence interval [CI] 15.74-21.24). After making single rows of pie-crust incisions on either side of the ellipse, the average closure force decreased to 12.14 N (95% CI 9.84-14.43,  $P < 0.0001$ ). After making second rows of pie-crust incisions on either side of the ellipse, the average closure force decreased further to 10.27 N (95% CI 8.21-12.33). This represented a further significant decrease in closure force beyond that after making the first set of pie-crust incisions ( $P < 0.0001$ ).

**Conclusion:** Multiple relaxing full-thickness skin incisions about open wounds significantly decrease tension during primary closure. These data seem to correlate with published clinical experience using this technique. It may represent a method that may be used to reduce the necessity of tissue transfer for closure of complex wounds and to improve the likelihood of closure of wounds in edematous tissue beds without undue tension.

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### **Clinical and Functional Outcomes of Patients Undergoing Anterolateral Versus Anteromedial Surgical Approaches for Pilon Fractures**

*Brett D. Crist, MD; Tyler Jenkins; Michael S. Khazzam, MD; Yvonne M. Murtha, MD; Gregory J. Della Rocca, MD, PhD; University of Missouri, Columbia, Missouri, USA*

**Purpose:** Our objective was to compare the rate and severity of complications, and functional outcomes between the anterolateral (AL) and anteromedial (AM) surgical approach used for open reduction and internal fixation (ORIF) of pilon fractures.

**Methods:** An IRB-approved medical record review of all operative pilon fractures managed using the AL and AM surgical approach between August 2005 and July 2009 was performed. 82 patients were identified. Rates of complications at final follow-up were determined. Phone interviews were performed to obtain MFA (Musculoskeletal Function Assessment) and FFI (Foot Function Index) scores after final follow-up.

**Results:** Complete data were available for 79 patients: AL approach (N = 42), AM (N = 33), and combined AM and AL (N = 4). All AL fractures were AO/OTA C fractures and ~40% were open. At final follow-up, the AM group had the highest number of secondary surgeries (2.48 average vs 1.5 for AL and AL/AM) and amputations (12% vs 9.5 AL vs 0 AL/AM). The combined AL/AM approaches had the longest interval to radiographic healing (451 days vs 294 AM vs 190 AL). Functional outcome data were available for 39 patients (AL 23 patients, AM 14 patients, AL/AM 2 patients). The average fracture classification for each group was AO/OTA C2-3 AL, B3-C1 AM, and C2-3 AL/AM. Time to outcome evaluation from injury was 1197 days AL, 1294 days AM, and 1223 days AL/AM. The average MFA scores were 40 AL/AM, 35.3 AL, and 32.6 AM. The average FFI scores were 57.2 AL/AM, 45.6 AL, and 42.1 AM.

**Conclusions:** Pilon fractures significantly affect patient function. Complications and functional outcomes of pilon fractures undergoing ORIF revealed that the AL and combined AL/AM groups had more complex fractures but fewer secondary procedures, and better outcome scores when compared to the AM approach. The combined AL/AM group had the longest time to radiographic healing. **When compared to the AM approach, the AL approach appears to result in fewer complications despite being used for more complex fractures.**



**Evaluation of the Reduction and Fixation of Calcaneus Fractures: A Delphi Consensus***M.S.H. Beerekamp<sup>1</sup>; J.S.K. Luitse<sup>1</sup>; M. Maas<sup>2</sup>; D. Ubbink<sup>3</sup>; N.W.L. Schep<sup>1</sup>;**J. Carel Goslings, MD, PhD<sup>1</sup>;**<sup>1</sup>Trauma Unit, Department of Surgery, Academic Medical Center, Amsterdam, The Netherlands;**<sup>2</sup>Department of Radiology, Academic Medical Center, Amsterdam, The Netherlands;**<sup>3</sup>Department of Quality and Process Innovations, Academic Medical Center, Amsterdam, The Netherlands*

**Background/Purpose:** Postoperative radiologic evaluation of the quality of calcaneus fracture reduction and fixation is essential when determining treatment effectiveness. **Despite** the awareness of its importance, an international **accepted scoring protocol** as a **guideline** for the postoperative evaluation of calcaneus fractures is currently unavailable. **The aim** of this study is to **obtain an expert-based consensus on the most important criteria** for the evaluation of the quality of fracture reduction and fixation of the calcaneus.

**Methods:** The Delphi method, consisting of three rounds of online questionnaires, was used to obtain consensus. Each questionnaire focused on four main topics of postoperative calcaneus fracture evaluation: imaging technique (38 items), anatomic aspects (21 items), fracture reduction (16 items), and position of the fixation material (9 items). We invited 10 radiologists and 44 surgeons (either general trauma or orthopaedic) from the USA and Europe (all calcaneus fracture specialists) to complete an online questionnaire. **The experts** were asked whether specific aspects of the above-mentioned topics require evaluation to determine the quality of fracture reduction and fixation. **Agreement was expressed as the percentage of responders with similar answers.** Consensus was defined as an agreement of at least 80%.

**Results:** All experts were invited for the three Delphi rounds and 16, 18, and 15 specialists responded per round. Agreement was reached for 23 of the 38 (60%) imaging techniques, 20 of the 21 (95%) aspects of the anatomy, 13 of the 16 (81%) items for the fracture reduction, and 8 of 9 items (89%) for fracture fixation.

**Conclusion:** In our consensus more aspects require evaluation than used in most radiologic scoring protocols. This implicates that current scoring protocols are not comprehensive enough. In addition, although angle and distance measurements are frequently used to describe aspects in the anatomy or quality of fracture reduction in the literature, according to our consensus, most aspects can be assessed visually in clinical practice. With this Delphi consensus we provide the basis to further develop a universal scoring protocol that can be useful in clinical practice.

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### **A Clinical Evaluation of Alternative Fixation Techniques for Medial Malleolus Fractures**

*Hayley Barnes, BS; Lisa K. Cannada, MD; J. Tracy Watson, MD;  
Saint Louis University Medical Center, Saint Louis, Missouri, USA*

**Purpose:** The current standard of treatment for medial malleolus fractures is reduction and fixation using partially threaded screws and/or Kirschner wire (K-wire) fixation. However, there have been reports of nonunion rates up to 20%. In addition, the patient may complain of prominent hardware. The purpose of this study is to report the outcomes of patients with medial malleolar fractures treated with headless compression screws in terms of union rates, the need for hardware removal, and pain over the hardware site.

**Methods:** After IRB approval, a review of medical records and radiographs was performed on patients with ankle fracture patients admitted to our Level I trauma center from 2007 to 2010. Patients were included in this study if they had headless compression screw fixation for the medial malleolus fracture in addition to follow-up until full weight bearing and fracture healing. Follow-up clinical records and radiographs were reviewed to determine the rate of union and perception of pain over the medial malleolus.

**Results:** 64 patients were treated with headless compression screws and 44 had adequate follow-up for inclusion. There were 17 males and 27 females with an average age of 45 years (range, 18-80). There were 23 patients with bimalleolar fractures, 14 with trimalleolar fractures, and 7 with isolated medial malleolar fractures. The majority of patients (59%) were injured in falls. The average follow-up was 35 weeks (range, 12-208). All patients were followed until union and full weight bearing. No patients requested/required hardware removal for prominence. One patient (2%) had a delayed union, which healed without additional intervention. 10 patients (23%) reported mild discomfort to palpation over the medial malleolus.

**Conclusion:** Headless compression screws have been used successfully for treatment of various fractures. We found the screws are useful in providing effective compression of medial malleolus fractures, especially as traditional fixation techniques involve unicortical screw fixation. Our series found no cases of nonunion. In addition, traditional cancellous screws or K-wires could be prominent and cause irritation, necessitating elective hardware removal. No patients in our series had hardware removal for this problem. A small percentage of patients reported mild discomfort to palpation over the surgical site, but overall, our series found treatment of medial malleolus fractures using headless compression screws resulted in good outcomes with no patient in this series with elective hardware removal for prominence and all medial malleolus fractures healed. The headless compression screw provides a viable alternative in medial malleolus fracture fixation.

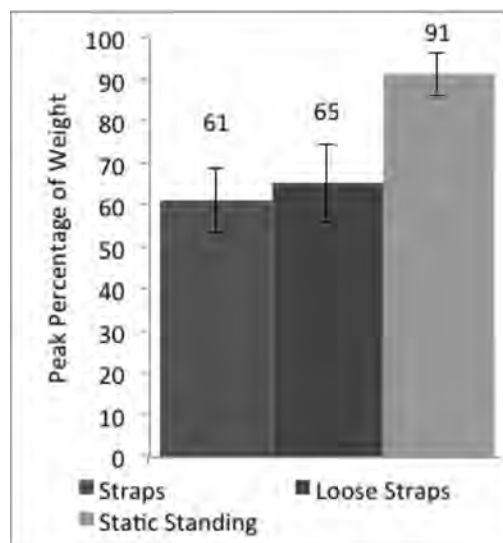
## CAM Walkers Only Diminish Lower-Extremity Loading in a Clinically Meaningful Way During Dynamic Loading

Kylee North; Ami R. Stuart, PhD; Thomas F. Higgins, MD; Robert W. Hitchcock, PhD; Erik N. Kubiak, MD;

University of Utah, Salt Lake City, Utah, USA

**Background/Purpose:** There are limited data to guide a clinician in regulating weight bearing after lower extremity fracture, so physician recommendations are often guided more by tradition than by evidence. Controlled ankle motion (CAM) walking boot casts are routinely prescribed for below-the-knee lower extremity fractures. These devices are thought to protect patients during ambulation. A better understanding of the effect of CAM walker immobilization on gait mechanics and fracture loading will facilitate more accurate postoperative weight-bearing prescriptions. The purpose of this study was to directly evaluate the effects of a CAM walker on peak plantar loading during static standing and gait.

**Methods:** 13 subjects without lower extremity pathology or balance deficits (mean age = 29) gave informed consent to participate and were enrolled in the IRB-approved study. Load sensors were positioned under the participant's right forefoot and heel. The right foot was then fitted with a CAM walker. Sensors were calibrated for each patient prior to ambulation. Participants were then asked to walk on a treadmill for 2 minutes while the straps of the boot cast were securely fastened and again while the straps of the calf portion of the boot cast were not securely fastened while the load sensor recorded load profiles. Load profiles recorded from the sensors were converted to a percentage of participant's weight. Peak loads were extracted from the load profiles and 50 peaks from the center of each walking trial were isolated and compared between the strap and loose strap condition using a paired Student *t* test ( $P < 0.05$ ).



**Results:** A significant decrease from static ( $91 \pm 5\%$ ) to dynamic ( $65 \pm 9.6\%$ ) loading was demonstrated. There was also a statistically significant increase in the peak percentage of weight captured from straps ( $61 \pm 7.5\%$ ) to the loose straps condition ( $65 \pm 9.6\%$ ). The figure displays the peak loads between the three conditions.

**Figure** Peak percentage of weight captured between three conditions. The difference between the straps and loose straps condition was significantly different ( $P < 0.05$ ).

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**Conclusion:** The CAM walker decreases the amount of weight experienced by the limb. The insole sensors were able to capture most of the participant's weight during static standing (91%); during ambulation, 61% to 65% of the weight was captured. The amount of decrease is dependent on the use of the CAM walker's strapping mechanism. Previous literature demonstrates that CAM walkers decrease peak loading by 30% to 37%. Our findings show that the previous literature fails to distinguish between dynamic and static usage of CAM walkers.

### Computed Tomography Assessment of Articular Reduction in Supination External Rotation Type IV (SER IV) Ankle Fractures

*Milton T.M. Little, MD; Marschall B. Berkes, MD; Lionel E. Lazaro, MD; Peter K. Sculco, MD; Rachel M. Cymerman, BA; Nadine Pardee; David L. Helfet, MD; Dean G. Lorich, MD; Hospital for Special Surgery/New York Presbyterian Hospital–Cornell, New York, New York, USA*

**Background/Purpose:** Plain radiography is currently considered the standard means of assessing anatomic reduction of operatively treated ankle fractures. However, precise evaluation of articular stepoff using this modality may be limited. CT scan has previously shown an improved ability to diagnosis syndesmotic malreduction and minimally displaced posterior malleolus fractures. The purpose of this study is to compare radiographic and functional outcomes between SER IV ankle fractures with CT-confirmed anatomic reductions (<2 mm articular stepoff) versus those with malreductions. We hypothesize that those fractures with CT confirmation of anatomic reduction will be associated with better functional, clinical, and radiographic outcomes when compared to those with CT confirmed malreductions.

**Methods:** 108 of 176 operatively treated SER IV ankle fractures patients fulfilled inclusion criteria consisting of 1 year of clinical follow-up, preoperative radiographs, postoperative radiographs, and Foot and Ankle Outcome Scores (FAOS). Preoperative MRI was performed for all patients to confirm SER IV pattern of injury and immediate postoperative CT scans were performed to assess fracture reduction (<2 mm articular stepoff). Radiographs were evaluated for tibiofibular clear space (TCS), and medial clear space (MCS) by two independent reviewers. Greater than 2-mm change in TCS or MCS between immediate and final postoperative radiographs was considered loss of reduction. The primary outcome evaluated was the FAOS. The secondary outcomes included postoperative range of motion and loss of reduction. Outcomes were compared between those fractures with or without 2 mm of articular displacement on CT scan.

**Results:** Anatomic reduction was present in 99 of the 108 patients. Mann-Whitney analysis of FAOS revealed significantly superior scores in the activities of daily living subcategory (94.1 vs 70.6,  $P = 0.01$ ) among those with confirmed anatomic reduction. There was no significant difference between groups with regard to all other subcategories of the FAOS. The anatomically reduced group had a significantly higher proportion of patients with normal postoperative plantar flexion ( $P = 0.043$ ). There was no difference between groups with regard to loss of reduction on plain radiographs.

**Conclusions:** This study supports the belief that articular reduction plays an important role in clinical outcome among ankle fractures treated with open reduction and internal fixation. Future investigations comparing the ability of plain radiography and CT scan to detect articular malreductions is warranted to better define the role for postoperative CT imaging.

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### The Changing Epidemiology of Open Ankle Fractures

*Kate E. Bugler, MD; Nicholas D. Clement, MBBS; Timothy O. White, MD;*

*Margaret M. McQueen, MD; Charles M. Court-Brown, MD;*

*Orthopaedic Trauma Unit, Royal Infirmary Edinburgh, Edinburgh, Scotland, United Kingdom*

**Purpose:** Open ankle fractures often present a significant clinical challenge. The management and outcome of these injuries has been extensively reported in the literature but there have been no reports of the epidemiology of this injury or how it has changed over time.

**Methods:** 178 adult patients with open ankle fractures presenting to our unit over a 22-year period, from 1988 to 2010, were included. Information recorded included age, gender, date and mechanism of injury, address, other injuries, and Gustilo-Anderson grade. As our unit is the only hospital with an adult orthopaedic department in the region and has a defined and stable catchment population, we were able to calculate the incidence of open ankle fractures.

**Results:** The incidence of open ankle fractures was  $1.49/10^5$ /year, representing 1.5% of all ankle fractures presenting over the same period. The mean age was 55 years, ranging from 16 to 96 years with the highest incidence occurring in women over the age of 90. The most common mechanism of injury was a simple fall or twist with only 26% of cases due to a motor vehicle collision (MVC). 82% of cases were isolated injuries. Social deprivation had no significant impact on the incidence but there was a difference in the mechanism of injury with the majority of injuries in the most deprived quintile caused by MVCs and significantly fewer due to simple falls ( $P = 0.047$ ). Over the 22 years there was a significant change in the mean age of the patients with open ankle fractures from 44 to 64 years ( $P = 0.03$ ). The overall incidence remained constant over the 2 decades. There was also a marked change in the prevalent mechanism of injury from predominantly MVCs in 1988 to simple falls in 2010.

**Conclusion:** In common with many traumatic injuries, open ankle fractures are increasingly low-energy insufficiency fractures affecting elderly patients, particularly older women. This has implications for service planning and training as well as the surgical intervention in these patients.

## Quantification of Bony Pelvic Exposure Through the Modified Stoppa Approach

Jesse E. Bible, MD; Ankeet A. Choxi, BE; Rishin J. Kadakia, BA;

Jason M. Evans, MD; Hassan R. Mir, MD;

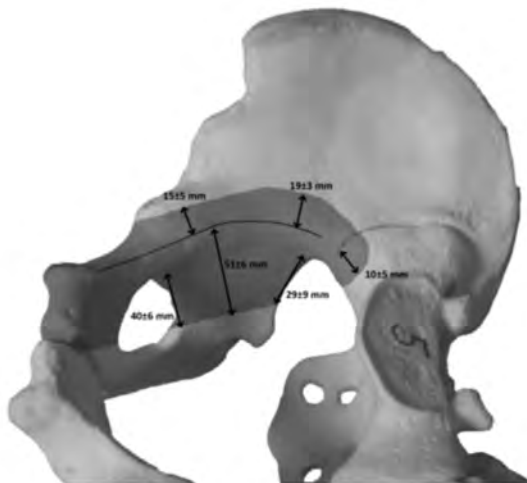
Vanderbilt Orthopaedic Institute, Nashville, Tennessee, USA

**Purpose:** Previous authors have described anatomic structures commonly seen through the modified Stoppa approach; however, no study has formally quantified the areas and amount of visual bony exposure that is obtained. This information is important for proper preoperative planning of acetabulum fractures with regard to fracture reduction and fixation. The aim of this study was to quantify and describe the extent of bony pelvis exposed, while identifying the limits of exposure from osseous landmarks within the dissection of a modified Stoppa approach.

**Methods:** Ten modified Stoppa approaches were performed on cadavers. Specific anatomic landmarks were identified, and the far boundaries of the exposed osseous structures from the surgeon's perspective were marked on each cadaver. All soft tissues were then stripped, and calibrated digital images were taken of the demarcated area of exposure and total viewable osseous surface area was calculated. Additionally, the boundaries of exposure based on various anatomic landmarks were determined.

**Results:** All neurovascular structures at potential risk (external iliac, obturator, corona mortis, and superior gluteal) were identified in each exposure. The entire pelvic brim from the pubic symphysis to beyond the sacroiliac joint was visualized in all exposures, with an average  $\pm$  standard deviation of  $10 \pm 5$  mm of anterior sacrum exposed. On average, visualization above the pelvic brim was possible  $15 \pm 5$  mm anteriorly over the acetabular roof, and  $19 \pm 5$  mm posteriorly above the greater sciatic notch. The viewable area included  $51 \pm 5$  mm below the pelvic brim along the quadrilateral surface, with  $41 \pm 5$  mm of the obturator foramen depth and  $29 \pm 9$  mm of the greater sciatic notch seen on average. Approximately  $32 \pm 4\%$  of the total surface area of the inner pelvis was able to be visualized, which included  $79 \pm 5\%$  of the inner true pelvis below the brim and  $80 \pm 6\%$  of the quadrilateral surface.

**Conclusions:** The modified Stoppa approach allows for safe exposure of the majority (79%) of the inner true bony pelvis including the entire pelvic brim and 80% of the quadrilateral surface. On average, visualization is possible 2 cm above the pelvic brim, and 5 cm below the pelvic brim along the quadrilateral surface, providing adequate anterior exposure for clamp and implant placement.



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**Anterior Pelvic Morphology: Implications for Medullary Ramus Fixation***Raymond D. Wright, Jr., MD<sup>1</sup>; David A. Hamilton, Jr., MD, MBA<sup>1</sup>; Milton L. Roult, Jr., MD<sup>2</sup>;**<sup>1</sup>Chandler Medical Center, University of Kentucky, Department of Orthopaedic Surgery and Sports Medicine, Lexington, Kentucky, USA;**<sup>2</sup>Harborview Medical Center, University of Washington, Department of Orthopaedics and Sports Medicine, Seattle, Washington, USA*

**Background/Purpose:** Sacral dysmorphism, which occurs in approximately one-third of the population, has been extensively discussed in the orthopaedic literature. One implication of sacral dysmorphism is that the operating surgeon needs to be aware of this anatomic variant if a posterior pelvic ring injury is to be secured with iliosacral screws. Medullary ramus screws fixation has been described as a technique to stabilize anterior pelvic ring injuries. This minimally invasive technique allows the surgeon to secure instability in the anterior pelvic ring with internal fixation by small incision surgery. Morphologic variation in the anterior pelvic ring has been described previously; however, no attempt has been made to correlate anterior morphology with posterior morphology. The objective of this study is to correlate anatomic variation of the superior pubic ramus with patient gender and the presence or absence of posterior ring dysmorphism.

**Methods:** 100 consecutive, skeletally mature patients without underlying bony pelvic pathology who underwent abdominopelvic CT scans were prospectively evaluated. Two-dimensional pelvic radiographic images were reconstructed from the CT studies for evaluation of the presence of posterior pelvic dysmorphism. Oblique CT studies oriented perpendicular to the superior pubic ramus were generated for each hemipelvis. Long screw accommodation by the osseous pathway was evaluated via individual examination of each superimposed axial section of the ramus to determine whether a single 3.5-mm screw could traverse the entire bony corridor without breaching the cortex. We define "long screw" as a screw extending the entire column of bone from the symphysis pubis to the cranial, posterior acetabular region.

**Results:** We evaluated 51 males and 49 females. 31 of 100 pelves demonstrated posterior dysmorphism. Among females, 18 (37%) were dysmorphic as compared to 13 (25%) of their male counterparts ( $P = 0.28$ ). Overall, 24 right hemipelves and 16 left hemipelves did not accommodate long superior ramus screws ( $P = 0.216$ ). There were 36 (36.7%) female hemipelves that did not accommodate a long screw compared to only 4 (3.9%) of male hemipelves ( $P < 0.0001$ ). Regardless of gender, 9 (14.5%) hemipelves associated with posterior pelvic dysmorphism did not accommodate long retrograde screws compared to 31 (22.5%) of hemipelves with normal posterior morphology ( $P = 0.252$ ). When considering the female cohort, 9 (25.0%) dysmorphic hemipelves could not accommodate long screws compared to 27 (43.5%) normal hemipelves, suggesting a trend toward positive correlation between sacral dysmorphism and the ability of the superior pubic ramus to accommodate a long screw in females ( $P = 0.084$ ).

**Conclusion:** The rate of sacral dysmorphism found in this study (31%) correlates with previous estimates of sacral dysmorphism prevalence. This rate does not appear to differ between males and females. Long, superior pubic ramus screws may be more difficult to



insert in female patients compared to male patients; this finding was statistically significant. Posterior dysmorphism does not itself seem to affect the likelihood of successful long screw insertion. However, for female patients, the presence of posterior dysmorphism may suggest an improved likelihood of safe intraosseous placement of a 3.5-mm screw within the superior pubic ramus. In our study, 78.4% of superior pubic rami would readily accommodate long screws. For fixation of anterior pelvic ring injuries, medullary screw fixation appears to be a safe and viable option for most of our study population. No previous study has attempted to correlate posterior pelvic morphology with anterior pelvic morphology. Further study is needed to determine which patients readily accommodate long superior pubic ramus screws.

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## Reliability of Qualitative Radiographic Characteristics of Upper Sacral Segment Dymorphism

Scott P. Kaiser, MD<sup>1</sup>; Michael J. Gardner, MD<sup>2</sup>; Joseph Liu, MD<sup>1</sup>;  
Milton L. Routt Jr., MD<sup>3</sup>; Saam Morshed, MD, MPH<sup>1</sup>;

<sup>1</sup>University of California San Francisco, San Francisco, California, USA;

<sup>2</sup>Washington University School of Medicine, Saint Louis, Missouri, USA;

<sup>3</sup>University of Washington, Seattle, Washington, USA

**Background/Purpose:** Iliosacral (IS) screws are commonly used to stabilize unstable injuries of the pelvis. Dymorphic sacra have altered orientation and cross-sectional area of the safe corridor for IS screw placement; however, no validated definition of this anatomic variation exists. Five qualitative characteristics associated with upper sacral segment dymorphism (USSD) can be recognized on the outlet radiograph. These characteristics are (1) an upper sacral segment not recessed in the pelvis, (2) the presence of mammillary processes, (3) an acute alar slope, (4) a residual disc between the first and second sacral segments, and (5) noncircular upper sacral neural foramina. The purpose of this study was to validate these qualitative assessments of USSD.

**Methods:** 100 CT scans from uninjured pelvises were analyzed. Volumetric holography was employed to create ideal outlet virtual radiographs of each subject. Two fellowship-trained orthopaedic traumatologists from Level I trauma centers analyzed each outlet view and assessed each of the five qualitative characteristics. Agreement rates and kappa coefficients were calculated. CT scans were reformatted to measure the coronal and axial orientation of the axis of the safe corridor with respect to the cardinal axes of the sacrum. The maximum length of a 10-mm-diameter tube around the axis of this safe corridor was then recorded for the upper and second sacral segments and cluster analysis was used to test the hypothesis that pelvises would group by these variables.

**Results:** The qualitative characteristics of USSD are common. Both reviewers independently noted the presence of each individual characteristic in 28% to 53% of the study cohort. Either or both reviewers in 33% of the study cohort noted at least four characteristics. Agreement between observers was between 70% and 81% and kappa coefficients ranged from 0.3 to 0.6, with acute alar slope being the most reliable characteristic and noncircular upper sacral foramina being the least. 41% of pelvises fell into a “dymorphic” cluster where an IS screw of no more than 120 mm in length (mean, 89 mm ± 25 mm) could be safely placed in the upper sacral segment, but a long IS screw (mean, 138 mm ± 16 mm) could be mapped in the second. Even after accounting for imperfect agreement, each of the five characteristics tested were significantly more frequently recorded ( $P < 0.007$ ) for subjects in this dymorphic cluster than in those where long IS screws could be mapped in both sacral segments.

**Conclusion:** USSD is associated with angulated and narrow bony corridors. In this radiographic study of 100 uninjured pelvises, there was a distinct cluster of subjects in which the safe corridor was short in the first sacral segment, and long in the second sacral segment. While interobserver reliability of identifying five qualitative radiographic characteristics was fair to moderate, each was present with significantly greater frequency in dymorphic pelvises. These characteristics of the dymorphic pelvic phenotype based on the outlet radiograph can aid surgeons in preoperative planning of safe IS screw placement for posterior pelvic ring stabilization.

See pages 97 - 144 for financial disclosure information.

### Computed Tomographic Measurement of Pelvic Landmarks in Minimally Displaced Lateral Compression Sacral Fractures: Comparison to Radiographic Measurements

*John Lien, MD<sup>1</sup>; John Lee, MD<sup>1</sup>; Joseph Maratt, MD<sup>1</sup>; Sven Holcombe, MS<sup>1</sup>;*

*Stewart Wang MD, PhD<sup>1</sup>; Paul Tornetta, III, MD<sup>2</sup>; James Goulet MD<sup>1</sup>;*

*<sup>1</sup>University of Michigan Health System, Ann Arbor, Michigan, USA;*

*<sup>2</sup>Boston Medical Center, Boston, Massachusetts, USA*

**Purpose:** Precise and reproducible measurement of pelvic fracture displacement allows monitoring of pelvic stability and detection of pelvic fracture site movement. The purpose of this study was to evaluate a new methodology of measuring pelvic displacement from CT picture archiving and communication system (PACS) data using a high throughput method and to compare the results with reported measurements using plain radiographs.

**Methods:** We evaluated the CT scans of 75 patients who presented to a single Level I trauma center with a unilateral lateral compression sacral fracture with <10 mm of displacement. Plain radiographic (XR) measurements were obtained by two independent observers. A vertical plumb line drawn through the center of the S1 and S2 vertebral bodies served as a midline reference. From this, key landmarks were measured on each side of the pelvis, including the superior border of the iliac wing, superior aspect of the sacral body, inferior aspect of the ischial tuberosity, sacral body width, and pelvic brim width. Corresponding pelvic CT scans were processed semiautomatically using MATLAB (The MathWorks Inc). Specific script files were formulated to correct pelvic rotation in the sagittal, coronal, and axial planes. After this correction, threshold processing allowed the identification of landmarks, and internal rotation of the affected hemipelvis was compared to the contralateral side. Landmark identification was verified by a blinded observer.

**Results:** CT and radiographic measurements were similar in value. The average displacements are displayed in the table below. Some displacements were positive (affected side displaced superiorly) while others were negative, indicating morphologic heterogeneity of LC1 (lateral compression 1) injury patterns. Absolute values were used to calculate average displacement. The injured hemipelvis was internally rotated an average of 2° compared with the contralateral side.

	Sacral Displacement	Iliac Wing Displacement	Ischial Displacement	Sacral Width Difference	Pelvic Ring Displacement
CT	2.1 mm	5.6mm	4.6mm	2.3mm	3.7mm
XR	1.6 mm	2.9mm	2.8mm	2.5mm	3.4mm

**Conclusion:** Using plain radiographs to measure specific pelvic landmarks is a reliable method to assess minimally displaced LC1 sacral impaction fractures. A high-throughput pelvis CT analysis program allows superior morphologic characterization of pelvic ring injuries. Previous CT studies have demonstrated a wide spectrum of pelvic rotation and

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translation with lateral compression injuries. These manually obtained measurements of CT displacement added considerable information to the characterization of pelvic fracture pathology. The current study demonstrates a near-automated method for determining CT displacement of pelvic fractures. This method allows large volumes of pelvic fracture-related CT data to be analyzed more rapidly and reproducibly than more conventional manual CT methods or measurement using plain films.

### Δ Biomechanical Mechanisms Underlying Preferential Peroneal Nerve Injury Following Acetabular Fracture and Surgery

Kanu Goyal, MD<sup>1</sup>; Michael Hill, PhD<sup>1</sup>; Hans C. Pape, MD<sup>1</sup>; John Moossy, MD<sup>2</sup>; Ivan S. Tarkin, MD<sup>1</sup>;

<sup>1</sup>Department of Orthopaedic Surgery, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, USA;

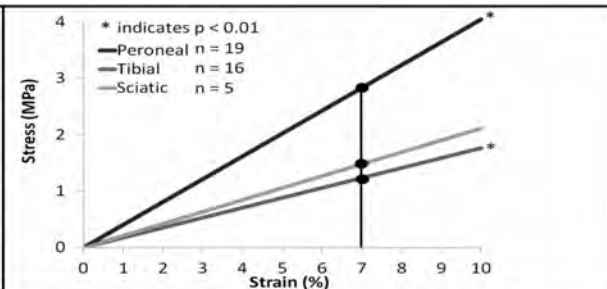
<sup>2</sup>Department of Neurosurgery, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, USA

**Purpose:** The peroneal nerve is preferentially injured in cases of sciatic nerve dysfunction after posterior acetabular fracture reconstruction. Fibular tunnel release at the knee may decrease strain with retraction at the hip. A biomechanical study was performed to determine whether the peroneal division of the sciatic nerve is stiff (compared to the tibial division) and thus more vulnerable to retraction injury.

**Methods:** The sciatic nerve and its peroneal and tibial divisions were dissected from eight human cadaver limbs from the hip to the knee. 50-mm segments were tested in tension with an Instron Electropuls E1000 to obtain the stress-strain response (Figure 1). Stress (in MPa) was defined as force (in N) divided by area (mm<sup>2</sup>), and strain was defined as percent change in specimen length. A straight line was fit to the linear region of this curve to obtain the stiffness, a material property independent of cross-sectional area. A balanced one-way analysis of variance was used to compare the means of the three stiffness data sets, assuming a 95% confidence interval. Further comparison between individual groups was performed with a Student *t* test ( $\alpha = 0.05$ ).



**Figure 1** Segment of a human nerve clamped in the tensile testing device



**Figure 2** Stress-strain response of three nerves. Black circles and line indicate stresses at a prescribed 7% strain.

**Results:** Significant differences in the mean stiffness between the peroneal, tibial, and sciatic nerves were found ( $P = 0.01$ ), and the peroneal nerve had a significantly higher stiffness than the tibial nerve (Figure 2).

**Conclusions:** Retraction of the sciatic nerve at the hip causes greater injury to the peroneal division due to its stiffer biomechanical properties. We determined that for a given constant applied force or constant strain, stress in the peroneal nerve is greater (compared to the tibial division). Fibular tunnel release at the knee may decrease the incidence of peroneal nerve injury by decreasing nerve stress and strain.

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## Reliability of Radiographic Measurement Techniques in Pelvic Ring Disruptions

Kelly A. Lefavre, MD<sup>1</sup>; Piotr A. Blachut, MD<sup>1</sup>; Adam J. Starr, MD<sup>2</sup>;

Gerard S. Slobogean, MD, MPH<sup>1</sup>; Peter J. O'Brien, MD<sup>1</sup>;

<sup>1</sup>University of British Columbia, Vancouver, British Columbia, Canada;

<sup>2</sup>University of Texas Southwestern, Dallas, Texas, USA

**Purpose:** The literature in pelvic ring disruptions is based largely on nonstandardized and nonvalidated radiographic outcomes. A thorough review of the literature revealed only three described methods for measuring radiographic displacement, and one frequently used grading system for displacement. We aimed to test the reliability of these previously published radiographic measurement methods and grading system.

**Methods:** Five separate observers measured radiographic displacement on the standardized pre- and postoperative AP, inlet, and outlet views of 25 patients with surgically treated Tile B and C pelvic fractures. The readers measured their initial impression based on the Tornetta and Matta grading system (excellent, good, fair, and poor). Next, they measured displacement using the inlet and outlet ratio as described by Sagi, the cross-measurement technique as described by Keshishyan, and the absolute displacement method (ADM) as described by Lefavre. The millimeter measurement obtained by the ADM was converted using the Tornetta and Matta grading system. Each continuous measure was compared for interobserver reliability using intraclass correlation coefficients (ICCs), and the categorical outcomes were compared using a kappa statistic. Finally, the relationship of the initial impression to the grade as determined by the ADM was compared using kappa agreement.

**Results:** The agreement among observers based on initial impression was poor (kappa statistic 0.306), but was fair among those reductions that were excellent ( $\kappa = 0.495$ ). Using the Sagi method, the reliability ICC was fair for the preoperative inlet (0.515, 95% confidence interval [CI] 0.338-0.702) and outlet ratios (0.594, 95% CI 0.423-0.760), but very good in postoperative radiographs (inlet: 0.814, 95% CI 0.703-0.901; outlet: 0.863, 95% CI 0.775-0.929). The ICC for all interpretations of the Keshishyan technique were excellent, but were highest when considered as a ratio (preop: 0.938, 95% CI 0.894-0.969; postop: 0.912, 95% CI 0.850-0.955). Using the ADM, the location and film used for measurement had poor agreement, and the ICC for the measurement in millimeters was fair (preop: 0.522, 95% CI 0.342-0.708; postop: 0.432, 95% CI 0.255-0.634), and the kappa agreement poor when converted using the Tornetta and Matta scale ( $\kappa = 0.2190$ ). The agreement between the impression and the converted grade from the ADM was poor ( $\kappa = 0.2520$ )

**Conclusions:** Radiographic measurement in pelvic radiographs to date has been nonvalidated, and we found the interobserver reliability on common methods, including overall impression and absolute displacement in millimeters, to be poor. The inlet/outlet ratio as described by Sagi was reliable only with wide displacement. The cross-measurement technique allows the least observer choice and had excellent reliability, but does not give a measurement that we can easily interpret based on convention in pelvic fracture description.

## Correlation of Acetabular Dysplasia With Hip Dislocation and Hip Fracture-Dislocations

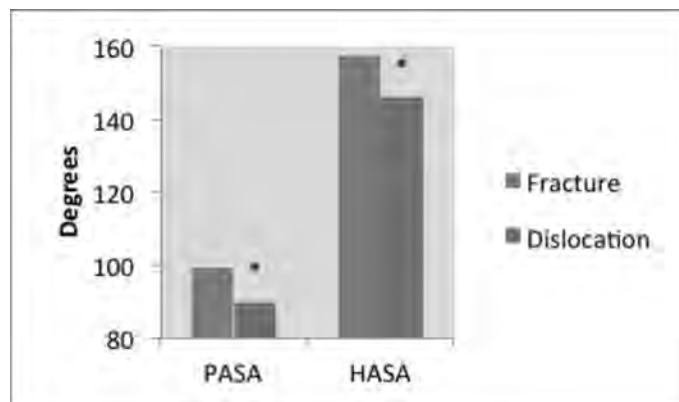
Kyle T. Judd, MD; Jason M. Evans, MD;

Vanderbilt University Medical Center, Nashville, Tennessee, USA

**Purpose:** Previous reports have described increased femoral anteversion in patients sustaining traumatic hip dislocations. To date, there have been no formal evaluations of the incidence of acetabular dysplasia in a similar population. Dysplasia may impact injury pattern by altering the amount of femoral head coverage at different hip positions. Our hypothesis was that patients sustaining simple hip dislocations would have increased prevalence of acetabular dysplasia when compared to patients sustaining posterior wall fractures of the acetabulum.

**Methods:** IRB approval was obtained from our local review board. Prospective subjects were identified by searching ICD-9 and CPT codes over a 10-year period. 36 patients who had sustained simple hip dislocations and 19 patients with isolated posterior wall fractures (62-A1) were identified for comparison. Center edge angle (CEA), direction of dislocation, and the presence of a crossover sign (COS) were evaluated. Postreduction CT scans for the dislocated hips were used to measure the anterior acetabular sector angle (AASA), the posterior acetabular sector angle (PASA), and the acetabular version (AV). The horizontal acetabular sector angle (HASA) was then calculated. For the patients sustaining posterior wall acetabular fractures, all measurement were taken from the uninvolved hip. Statistical analysis was carried out via Wilcoxon and Pearson tests.

**Results:** 83% of dislocations were posterior in nature. Presence of COS was 58% (dislocations) and 33% (fractures). Average CEA was 38.1° (dislocations) and 40.9° (fractures). Acetabular anteversion and AASA was 14.8°/56.0° and 16.9°/58.1° for the dislocation and fracture groups, respectively. PASA and HASA were 99.0° and 89.8° ( $P=0.006$ ) and 157.1° and 145.9° ( $P=0.005$ ) for the fracture and dislocation groups.



**Figure.** PASA and HASA for the fracture and dislocation groups. \*Denotes statistically significant difference

**Conclusion:** These data clearly identify differences in acetabular anatomy between groups of patients sustaining two very different injury patterns thought to be caused by similar

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mechanisms. These differences may play a role not only in injury pattern but clinical outcome as well, because the cumulative effect of dysplasia and the soft-tissue injury sustained at dislocation is currently unknown. Future evaluation of the clinical significance of dysplasia in patients sustaining dislocations of the hip will provide valuable information in the treatment of this subset of patients.



### **Δ Nerve Microstructure and Composition Underlying Preferential Peroneal Nerve Injury After Acetabular Fracture and Surgery**

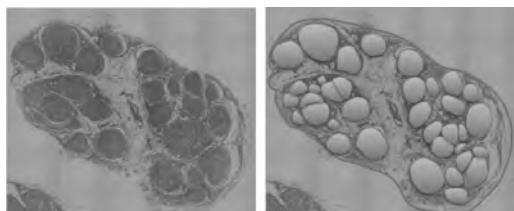
*Kanu Goyal, MD<sup>1</sup>, Sean Flynn, BS<sup>1</sup>; Michael Hill, PhD<sup>1</sup>; Hans C. Pape, MD<sup>1</sup>;  
John Moossy, MD<sup>2</sup>; Ivan S. Tarkin, MD<sup>1</sup>;*

*<sup>1</sup>Department of Orthopaedic Surgery, University of Pittsburgh Medical Center,  
Pittsburgh, Pennsylvania, USA;*

*<sup>2</sup>Department of Neurosurgery, University of Pittsburgh Medical Center,  
Pittsburgh, Pennsylvania, USA*

**Purpose:** Peroneal nerve dysfunction after posterior acetabular fracture reconstruction is potentially avoidable if the fibular tunnel at the knee is released prior to sciatic nerve manipulation at the hip. The aim of the current study is to demonstrate histologically the basis for the increased incidence of compression and strain-induced injury to the peroneal division of the sciatic nerve versus the tibial division, which is injured less commonly.

**Methods:** Complete sciatic nerves were harvested from six fresh-frozen human cadaveric lower extremities. The peroneal and tibial divisions were dissected from the sciatic sheath as proximal as possible. In 4 of 6 cases, this was reliably performed up to the sciatic notch; in 2 cases, this was done up to midthigh. For each nerve, 1 to 2 samples were taken at the level of the knee and at the level of the hip for analysis. The nerves were fixed in paraformaldehyde, stained with hematoxylin and eosin, and imaged using a motorized scope. Total nerve cross-sectional area and individual fascicular area were measured with MetaMorph. Connective tissue (epineural) area, average fascicular area, and fascicular/epineural area ratio were calculated (figure). Statistical analysis was performed with paired *t* tests ( $\alpha = 0.05$ ).



**Figure**  
Method for calculating nerve total and fascicular cross-sectional area.

**Results:** At the hip, the total cross-sectional area and number of fascicles of the peroneal nerve were significantly less than the tibial nerve but there was no difference in the average fascicular area (table). The peroneal nerve also had a significantly higher ratio of fascicular/epineural area than the tibial nerve. At the knee, the peroneal nerve had a significantly smaller total cross-sectional area and fewer fascicles than the tibial nerve. There was no difference in the average fascicular area or the fascicular/epineural area of the two nerves (table).

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**Table** Histologic measurements

<b>Hip</b>	<b>Peroneal (n = 6)</b>		<b>Tibial (n = 6)</b>		<i>P</i> Value
	Avg	SD	Avg	SD	
Total area (mm <sup>2</sup> )	19.9 ±	9.15	51.7 ±	29.4	0.021
# of fascicles	34.8 ±	10.5	73.2 ±	34.7	0.024
Avg fasc. area (mm <sup>2</sup> )	0.139 ±	0.032	0.15 ±	0.046	0.512
Fasc area/epineural area	0.370 ±	0.167	0.295 ±	0.125	0.026
<b>Knee</b>	<b>Peroneal (n = 10)</b>		<b>Tibial (n = 10)</b>		<i>P</i> Value
	Avg	SD	Avg	SD	
Total area (mm <sup>2</sup> )	17.6 ±	6.49	32.3 ±	12.4	0.001
# of fascicles	26.8 ±	12.8	52.4 ±	23.7	0.001
Avg fasc. area (mm <sup>2</sup> )	0.165 ±	0.089	0.159 ±	0.079	0.82
Fasc area/epineural area	0.314 ±	0.176	0.338 ±	0.209	0.63

**Conclusions:** The diminutive microstructure of the peroneal nerve is more prone to compression and strain-induced injury (as compared to the tibial nerve). The peroneal nerve has a smaller cross-sectional area and fewer fascicles at the hip and knee and less connective tissue per fascicle than the tibial nerve at the hip. This may make the peroneal nerve more prone to pressure-related injury than the tibial nerve.

### **Pelvic CT-Based Modeling for Placement of Safe Transsacral Screws and Identification of Sacral Dymorphism**

*Soham Banerjee, BS; Adam Starr, MD; Rahul Banerjee, MD;  
UT Southwestern Medical Center, Dallas, Texas, USA*

**Background/Purpose:** Placement of iliosacral screws is challenging due to the variability in the anatomy of the sacrum and sacroiliac joints. Transsacral screws may provide additional stability by spanning the sacrum and engaging the ilium on both sides. Placement of transsacral screws is limited in patients with sacral dymorphism. We have previously described a CT-based computer algorithm that identified a safe pathway for placement of anterior and posterior column screws. The purpose of our present study was to apply this algorithm to identify a safe pathway for placement of transsacral screws and to identify patients with sacral dymorphism.

**Methods:** 87 trauma patients with uninjured sagittal pelvic CT images were analyzed using a software algorithm that we have previously described. For each CT, the algorithm distinguished bone from soft tissues and modeled these structures into detailed polygons. The polygons were used to create a three-dimensional graphical model for each CT scan. The algorithm then generated a list of possible transsacral screw starting points on the left ilium. From each of these points a potential 10-mm screw pathway was graphically projected through the ilium along the S1 segment, and exiting the far ilium. We chose 10 mm to simulate the amount of maneuverability that a surgeon may require to safely insert a 6.5-mm or 7.3-mm screw. Screws that did not remain safely within the bone were eliminated. The process was then repeated for the S2 segment. In patients who could not accommodate a safe transsacral screw, we examined the plain films and CT to identify features of sacral dymorphism.

**Results:** 64 of 87 patients (85%) were able to safely accommodate a transsacral screw at the S1 segment. The average length of the safe transsacral screw at S1 was 115 mm. 63 of 87 patients (84%) were able to safely accommodate a transsacral screw at the S1 segment. The average length of the safe transsacral screw at S2 was 117 mm. The computer algorithm identified 13 of 87 patients (15%) who were unable to safely accommodate a transsacral screw at the S1 segment. 14 patients (16%) could not accommodate a safe transsacral screw at the S2 segment. In one patient, neither the S1 nor S2 segment could accommodate a safe transsacral screw. Patients who were unable to safely accommodate an S1 or S2 transsacral screw demonstrated radiographic signs of sacral dymorphism (such as the presence of residual disks, sacralization of L5, presence of mammillary bodies, and/or a prominent sacral promontory).

**Conclusion:** We have applied our CT-based modeling algorithm to identify safe pathways for placement of transsacral screws. Our study confirms that sacral dymorphism eliminates the ability to place a safe transsacral screw. There may be a role for CT-based analysis and computer guidance in the placement of iliosacral screws.

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**Clinical and Economic Impact of Generic 7.3mm Cannulated Sacroiliac Screws***Justin R. Kauk, MD<sup>1</sup>; Peter L. Althausen, MD<sup>1</sup>, MBA; Daniel J. Coll, MHS, PA-C<sup>2</sup>;**Timothy J. O'Mara, MD<sup>1</sup>; Timothy J. Bray, MD<sup>1</sup>;*<sup>1</sup>*Reno Orthopaedic Clinic, Reno, Nevada, USA;*<sup>2</sup>*Renown Regional Medical Center, Reno, Nevada, USA*

**Background/Purpose:** In today's climate of cost containment in the healthcare industry, exploring generic implant alternatives represents an interesting area of untapped resources. Traditional implant companies develop their proprietary implants and are in direct competition with each other. However, unlike the pharmaceutical industry there are no generic equivalents available to help lower the implant costs to hospitals, insurance carriers, and patients. The purpose of this study was to examine the costs, implementation, and outcome of a cost containment program utilizing generic implants of equivalent quality.

**Methods:** The contracted orthopaedic traumatologist at our institution adopted the use of generic 7.3-mm cannulated screws in January 2011. Despite a much lower cost, these screws were biomechanically tested as equivalent to major implant company products prior to the initiation of the project. Review of our trauma database identified patients with posterior pelvic ring injuries treated with generic 7.3-mm cannulated screws. These patients were compared to patients treated in a similar manner from 2010 with conventional implants. Chart review was undertaken to obtain basic demographic variables such as age, sex, and American Society of Anesthesiologists (ASA) status. Operative records were reviewed to identify any intraoperative complications, operative time, and estimated blood loss. Radiographs were reviewed by a blinded author to record injury type, healing time, screw cutout, screw deformation, screw loosening, and/or loss of fixation. Hospital financial records were accessed to determine operative costs, and total hospital charges.

**Results:** Review of our institutional database identified 50 patients treated with generic 7.3-mm cannulated screws in 2011 and 62 treated with conventional implants in 2010. There were no significant differences in age, sex, ASA status, or fracture pattern between the two groups. No increase in operative time, estimated blood loss, complication rate, screw cutout, screw deformation, or loosening was noted. Overall our hospital realized a 62% reduction in implant costs, resulting in \$14,742 savings for the calendar year.

**Conclusions:** Use of generic 7.3-mm cannulated sacroiliac screws has been a very successful endeavor at our institution. Hospital implant costs were decreased significantly without any associated increase in complication rate or radiographic outcome. This has profound implications for the treatment of trauma patients as patents have expired on many other products such as intramedullary nails, locking plates, and disposable items such as drill bits. Generic implant usage has the potential to markedly reduce operative costs in a manner similar to the generic pharmaceutical industry. As long as quality products are utilized, patient care is unaffected and cost savings can be realized. A portion of savings from such a change can be reinvested in the hospital trauma program to support OTA/AAOS position statement guidelines and positively affect the cost of hip fracture implants in the future.

See pages 97 - 144 for financial disclosure information.

**Combat-Related Hemipelvectomy: Eleven Cases, a Review of the Literature, and Lessons Learned**

*Jean-Claude G. D'Alleyrand, MD<sup>1,2</sup>; Mark Fleming, DO<sup>1,2</sup>; Wade T. Gordon, MD<sup>1,2</sup>; LTC Romney C. Andersen, MD, MC, USN<sup>1,2</sup>; Brian Mullis, MD<sup>1</sup>; Benjamin K. Potter, MD<sup>1,2</sup>;*

*<sup>1</sup>Integrated Department of Orthopaedics and Rehabilitation,*

*Walter Reed National Military Medical Center, Bethesda, Maryland, USA;*

*<sup>2</sup>Norman M. Rich Department of Surgery, Uniformed Services University of Health Sciences, Bethesda, Maryland, USA*

**Background/Purpose:** Trauma-related hemipelvectomy is a rare, devastating, and often fatal injury that poses a number of challenges to the treating orthopaedic traumatologist. Treatment of these injuries typically requires intense effort by providers from multiple services, to include orthopaedics, general surgery, urology, critical care, and infectious disease. Few cases of this injury have been reported, with fewer than 70 cases described in the 20th century. Unfortunately, we have had a unique experience with a number of combat-related hemipelvectomies over the last 2.5 years. The purpose of this paper was to identify unique patient and injury characteristics that proved difficult to manage, as well to describe our operative and medical management techniques for these challenging patients.

**Methods:** Over the last 2.5 years, our institution has treated 11 patients who have had significant injuries to the proximal thigh and pelvic girdle requiring hemipelvectomy for definitive treatment. We performed a retrospective review of our prospective trauma registry into which all our combat-injured patients are enrolled, as well as patient medical records, radiologic studies, and clinical photographs.

**Results:** Hemipelvectomy was generally indicated for insufficient soft-tissue coverage complicated by life-threatening local infection and/or a necrotic and dysvascular hemipelvis following early ligation of critical intrapelvic vasculature. Six of the patients had acquired an aggressive, angioinvasive fungal infection, for which hemipelvectomy was performed in order to treat invasion into the true pelvis. Treatment of these difficult infections involved not only débridement of pelvic contents, but also topical diluted bleach solutions plus local and systemic antifungals. Associated genitourinary trauma was the norm. Extended hemipelvectomy consisting of concurrent partial sacrectomy was required in one patient. However, of the nine surviving patients in this series, he is one of only two patients to return to ambulation. Subtotal hemipelvectomy was performed in five patients in efforts to improve sitting balance and/or prosthetic socket support or to minimize pressure ulcers over the sacrum.

**Conclusions:** Trauma-related hemipelvectomy is a catastrophic injury that leaves little margin for error on the part of the treating surgeon and medical team. The present series represents one of the largest single-center cohorts reported to date. The high survival rate in our patients, despite their significant multisystem morbidity, appears to have resulted from initial rapid resuscitation as well as an extremely aggressive surgical approach to gain control of local infections and achieve a viable adjacent soft-tissue envelope. Since our patients were injured as the result of explosive devices, their injury mechanisms represent the highest level of energy. Accordingly, our experience and management techniques may benefit the civilian surgeon confronted with high-energy open injuries to the pelvic girdle.

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**• Biomechanical Evaluation of a Percutaneous Fixation System for the Treatment of Unstable Posterior Pelvic Ring Injuries**

Jonathan Vigdorichik, MD<sup>1</sup>; Amanda O. Esquivel, PhD<sup>1</sup>; Xin Jin, PhD<sup>2</sup>; King H. Yang, PhD<sup>2</sup>; Darren T. Herzog, MD<sup>1</sup>; **Bryant W. Oliphant, MD<sup>1</sup>**; Rahul Vaidya, MD<sup>1</sup>;

<sup>1</sup>Detroit Receiving Hospital/Detroit Medical Center, Detroit, Michigan, USA;

<sup>2</sup>Wayne State University Department of Biomedical Engineering, Detroit, Michigan, USA

**Purpose:** A new device was developed for the percutaneous treatment of posterior pelvic ring injuries. The goal of this system is that it could be used instead of previously tested constructs, namely sacroiliac (SI) screw fixation, and possibly outperform this other modality. The hypothesis of this study is that this percutaneous posterior fixation system (PPFS) is stronger in maximum load and stiffness than either single or dual SI screw fixation in two unstable pelvic models: (1) SI joint diastasis with symphyseal disruption (61-C1.2) and (2) a transforaminal sacral fracture (61-C1.3).

**Methods:** Composite pelves were used for all testing with the SI diastasis model supplied directly from the manufacturer and a sacral fracture was created in the other model with 1-cm gap. Each construct was tested in 6 pelvic models of SI disruption and 6 pelvic models of a sacral fracture with a compressive load in single-leg stance: (1) one S1 iliosacral screw, (2) S1 + S2 iliosacral screws, (3) the PPFS, and (4) the PPFS in addition to an S1 screw. Displacement was recorded at the pubic symphysis and SI joint using high-speed capture video. Ultimate load and displacement were measured, and axial stiffness was calculated. Values were compared using a 2-way analysis of variance with Bonferroni adjustment ( $P < 0.05$ ). The PPFS tested involves the use of pedicle screws placed in a percutaneous manner starting at the posterior superior iliac spine, traveling between the cortical tables and ending just above the sciatic notch. A connecting bar is used that is tunneled subcutaneously and through a hole created in the intervening spinous process. The construct is then connected and secured with the appropriate endcaps.

**Results:** One S1 screw ( $P < 0.001$ ) and S1 + S2 screws ( $P < 0.001$ ) were significantly stiffer than the PPFS in the SI joint disruption model. In the sacral fracture model, S1 + S2 screws allowed significantly less displacement, resisted a greater load, and were stiffer than one S1 screw or the PPFS construct ( $P < 0.001$ ). The S1 screw was similar in stiffness to the PPFS alone in the sacral fracture model, where compression was not possible. In the sacral fracture model, the PPFS + S1 construct was significantly stiffer than the one S1 screw, the PPFS, and S1 + S2 construct ( $P < 0.001$ ).

**Conclusions:** The PPFS construct appears to give additional strength in an unstable sacral fracture model when combined with an SI screw. However, on its own, this device is significantly weaker than a single S1 screw in SI disruptions or an S1 + S2 screw in our sacral fracture model. The strongest construct in the sacral fracture model was the S1 screw with the PPFS. Its price makes it prohibitive in cases where SI screws are feasible and consideration should be given to standard fixation methods when possible.

### **A Prospective Randomized Comparison of Two Skin Closure Methods in Acetabular Fracture Surgery**

*Christopher D. Mudd, MD; John A. Boudreau, MD; Berton R. Moed, MD;  
Saint Louis University School of Medicine, Saint Louis, Missouri, USA*

**Background/Purpose:** The posterior surgical approach to the acetabulum requires an extensive dissection, making it prone to wound complications such as persistent drainage and deep infection. An overall infection rate of approximately 5% with the use of the Kocher-Langenbeck approach has been reported. Using metallic staples to close hip skin incisions has been considered the gold standard. The purpose of this study was to determine whether closure of the skin with a running subcutaneous suture and then sealing the wound with 2-octylcyanoacrylate (OCA; Dermabond, Ethicon) would result in a decreased rate of infection and wound drainage when compared to closure with staples.

**Methods:** An a priori power analysis was preformed indicating a sample size of 100 patients (50 per group) would be sufficient for statistical power of greater than 0.80. Between 2006 and 2010, 103 patients with acetabular fractures treated using the Kocher-Langenbeck approach were enrolled and randomized into two groups: closure of skin with metallic staples (52 patients) versus subcutaneous running Monocryl suture (Ethicon) with OCA application (51 patients). Deep and superficial closed suction drains were inserted in all patients prior to closure. Additionally, a sponge vacuum suction device was placed on surgical wounds and/or drain holes with copious persistent drainage at the discretion of the attending surgeon. The amount of drainage, time to drain removal, time to wound dry, time to drain holes dry, and signs of infection were recorded. All patients were placed on a standard anticoagulation regimen for venous thromboembolism prophylaxis. All patients were followed postoperatively for a minimum of 1 year.

**Results:** Two deep infections occurred in the staple group requiring repeat surgical intervention. No infections were observed in the group closed with OCA ( $P = 0.495$ ). There were no superficial infections. Comparing days from surgery to dry incision showed the only statistical difference between groups, favoring OCA (4.2 vs 5.9 days,  $P = 0.032$ ).

**Conclusions:** Closure with subcutaneous Monocryl sutures and OCA has no disadvantages and may demonstrate a decreased infection rate when compared to staples. In addition, the OCA and suture closure led to a dry incision more quickly than staples. Therefore, we recommend closure of Kocher-Langenbeck incisions using this technique based on the clinically important benefit of achieving a dry wound more expediently.

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**Early Failure of Symphysis Pubis Plating: Analysis of Injury and Fixation Factors**

*Jonathan G. Eastman, MD; James C. Krieg, MD; Milton L. Routt, Jr., MD;  
Harborview Medical Center, Seattle, Washington, USA*

**Purpose:** Our objective was to analyze a series of patients who experienced pubic symphysis plate failure within 7 weeks and report associated injury and patient factors.

**Methods:** Through a retrospective review of a prospectively collected trauma database, 126 patients were identified who had a pelvic ring injury treated with open plating of the symphysis pubis from December 2009 to December 2011. A senior orthopaedic traumatologist at our regional Level I trauma center treated each patient. Surgical intervention included open pubic symphysis stabilization with a flexible 6, 8, or 10-hole 3.5-mm reconstruction plate and percutaneously placed iliosacral screw fixation. Postoperative protocol had patients with toe-touch weight bearing on the injured side. Each patient's chart and radiographs were reviewed for pertinent information. This included patient sex, age, mechanism of injury, AO/OTA, and Young and Burgess injury classification, type of fixation used, preoperative and postoperative pubic symphysis displacement, time until anterior ring failure, mode and location of construct failure, symphysis pubis displacement at time of failure, presence of additional future displacement, incidence of secondary surgery, and evidence of patient compliance.

**Results:** From this cohort, 14 patients sustained early failure of their anterior ring (11.1%). All patients who failed were male. Average age was 49.3 years (range, 30-65). AO/OTA classification showed 11 patients with B1-B1.1 injuries, 2 patients with C1.2 injuries, and 1 patient with a B1-B2.2 injury. 13 patients were classified as anteroposterior compression-II (APC-II) injuries and 1 patient sustained an APC-III injury. Mechanism of injury in the early failure patients was 42% equestrian and 29% fall from height. Average preoperative anterior ring displacement was 35.6 mm (range, 20.8-52.9). Average immediate postoperative displacement was 6.3 mm (range, 4.7-9.3). Time until anterior plate failure was 29 days (range, 12-47). All plates failed through the parasymphyseal holes except for one construct with catastrophic unilateral screw back-out. Average displacement at time of radiographic failure was 12.4 mm (range, 5.6-20.5). Average increased displacement noted at final clinical follow-up was an additional 2.6 mm (range, 0.2-6.9). Length of clinical follow-up averaged 160 days (range, 31-414). Two patients underwent revision surgery. Four patients were noted to be noncompliant prior to failure.

**Conclusion:** Early failure of the pubic symphysis plate in patients treated with anterior and posterior pelvic fixation is not uncommon. Equestrian-related injuries represent a high percentage of early failures in this series. Patient education is critical to help ensure postoperative weight-bearing restriction compliance. Further displacement after initial failure was not substantial and only two patients required a revision surgery. When early failure of anterior pelvic fixation occurs in patients whose injuries were initially treated with both anterior and posterior fixation, it is not an absolute indication for revision surgery. Having robust posterior ring fixation may help minimize further displacement after early anterior plate failure. Further clinical monitoring is needed to determine the long-term outcome of patients with early failure.

See pages 97 - 144 for financial disclosure information.



### Defining the Spectrum of APC II Pelvic Fractures: A Radiographic Assessment of 42 Consecutive Cases

Brian M. Tonne, MD; Laurence B. Kempton, MD; Madhav A. Karunakar, MD;  
Carolinas Medical Center, Charlotte, North Carolina, USA

**Purpose:** Anterior-posterior compression (APC) II injuries represent a spectrum of injury with increasing disruption of the sacroiliac (SI) joint complex. A recent study has suggested that an examination under anesthesia (EUA) can identify an APC IIb variant that may require posterior fixation based upon 1 cm of dynamic vertical displacement of the pubis with push-pull examination. The purpose of this study was to objectively measure disruption of the SI joint complex to determine if a static radiographic definition of the APC IIb variant could be defined.

**Methods:** An IRB-approved retrospective review identified 61 patients with APC II injuries between January 2004 and April 2011. 7 patients were excluded due to age <18 years and 12 due to follow-up <3 months, leaving 42 for analysis. 29 (69%) received anterior fixation only while 13 (31%) received anterior and posterior fixation. Standardized measurements were recorded for symphyseal diastasis, SI joint widening, static vertical ramus offset (relative displacement of pubic bodies on AP and outlet views), and posterior shift at the SI joint (posterior displacement of the ilium on the axial CT cut just above the greater sciatic notch). If a binder was placed, residual symphyseal diastasis and residual vertical and AP offset were measured on the CT scan and recorded. In order to determine the reliability of identifying a IIb pattern, APC IIa and IIb were alternatively defined by using two different criteria as follows: (1) absence (IIa) or presence (IIb) of posterior fixation indicating surgeon opinion; (2) absence (IIa) or presence (IIb) of posterior shift >0 mm. The radiographic measurements were then analyzed to determine if any differences could be identified between the two APC subtypes based upon either classification method.

**Results:** There were no catastrophic failures requiring revision fixation regardless of treatment or subclassification. When IIa and IIb subtypes were defined by surgeon opinion, there were significant differences for SI joint anterior width ( $P < 0.0001$ , mean 7.0 and 12.1 mm), central width ( $P = 0.0001$ , mean 8.2 and 11.0 mm), and posterior shift ( $P = 0.0036$ , mean 1.0 and 3.7 mm). Mean static vertical ramus offset was 10.1 mm (IIa) and 13.8 mm (IIb);  $P = 0.23$ . Objective classification into APC IIa and IIb based on posterior shift demonstrated a significant difference in anterior SI widening ( $P = 0.0008$ , mean 6.9 and 10.5 mm), static vertical ramus offset ( $P = 0.0279$ , mean 8.6 and 14.7 mm), symphysis diastasis ( $P = 0.0345$ , mean 31.3 and 40.7 mm), hardware loosening ( $P = 0.05$ , 17% and 44%), residual vertical offset ( $P = 0.0025$ , mean 2.9 and 7.0 mm), and residual AP offset ( $P = 0.0476$ , mean 3.3 and 6.4 mm) after pelvic binder placement.

**Conclusions:** (1) Static vertical ramus offset >1 cm was commonly seen regardless of subclassification or treatment, suggesting that this cutoff for a dynamic measurement during EUA likely overrepresents the need for posterior fixation. 48% of our patients treated with anterior fixation alone may have undergone unnecessary posterior fixation as their static vertical ramus offset was 1 cm or greater. (2) Experienced surgeon opinion (treatment ren-

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dered) correlates with objective measurements of SI joint disruption and identifies APC II subtypes that may benefit from selective posterior fixation. (3) The significant association between posterior shift and residual vertical ( $P = 0.0025$ ) and AP ( $P = 0.0476$ ) offset following binder placement suggests that objective measurements on injury CT scans may predict increased posterior injury (APC IIb pattern). (4) While we were able to identify a discrete APC IIb subtype based on posterior shift, it remains unclear which injuries, if any, mandate posterior fixation as the only clinical difference was a higher rate of hardware loosening ( $P = 0.05$ ) in patients with measurable posterior shift regardless of fixation method.

### Examination Under Anesthesia for Posterior Wall Acetabular Fracture: A Survey of the OTA Membership

*John Riehl, MD; Kenneth J. Koval, MD; Joshua Langford, MD;  
Mark W. Munro, MD; George J. Haidukewych, MD;  
Orlando Regional Medical Center, Orlando, Florida, USA*

**Background/Purpose:** Historically, acetabular fractures that involve 20% to 40% of the posterior wall (PW) as seen on axial CT scan (intermediate PW fractures) have been classified as indeterminate with respect to hip stability. Therefore, dynamic stress views under anesthesia have been recommended for these patients. Controversy, however, surrounds both the indications and technique of examination under anesthesia (EUA) to determine hip stability for patients with PW fractures. The purpose of this survey was to learn more about the criteria and methods of performing EUA for “intermediate”-sized PW fractures and to find what criteria surgeons use to determine hip instability.

**Methods:** A link to an 18-question survey was posted on the OTA web site from October 20, 2011 to January 31, 2011. The questions asked about both the indications and methods for performing the EUA as well how instability was determined. Responses were anonymously recorded into a spreadsheet and later were tabulated.

**Results:** 36 surgeons responded to the questionnaire. 29 of 36 of the respondents practice at a Level I trauma center. 19 respondents had >10 years in practice and 35 had trauma fellowship training. 21 respondents treated >20 acetabular fractures per year, while 32 treated >10 per year. 33 of 36 said that they do perform EUAs to evaluate select PW acetabular fractures, while 3 said that they do not. Indications cited for performing an EUA for a PW acetabular fracture included: (1) any small acetabular fracture (<20% of the PW, 13 respondents); (2) any PW with an associated hip dislocation (14 respondents); and (3) any PW fracture measuring 20% to 40% of the PW (23 respondents). Almost all (33 of 34) said they use live fluoroscopy ± static films to evaluate the hip during the examination. The majority of respondents use a combination of views (most commonly AP and obturator oblique). 24 of 35 respondents said the obturator oblique view is the most important view. Considerable variability existed regarding the positions surgeons put the hip in during evaluation. More respondents (18) said they test the hip in flexion/adduction/internal rotation than any other position. Flexion and adduction only was the next most common position (5 respondents). 30 of 34 respondents said they apply axial load to the femur, and most said they do this in all positions tested. All respondents who answered question 14 said that even subtle subluxation of the hip defined instability on examination. With an associated dislocation, 16 of 34 said that they do not change their management of the small PW fracture. Seven said they would fix the PW regardless of the size without doing an EUA if there was a dislocation. 11 respondents said they would also change their management with an associated dislocation by performing an EUA on a small PW fracture, as opposed to immediate nonoperative treatment.

**Conclusion:** Considerable variability exists with regard to criteria and methods of performing EUA for PW acetabular fractures. The published literature advocates for EUA of intermediate-size PW fractures. Interestingly, while 92% of our respondents believe in the

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utility of EUAs, only 64% perform an EUA for an “indicated” intermediate-size fracture (20% to 40% of the PW). The vast majority (>90%) of surgeons surveyed will perform an EUA with the patient supine, anesthetized, and stress the hip in many positions using live fluoroscopy. Any subluxation is considered abnormal and warrants surgical intervention. The most useful “live” fluoroscopic view according to survey participants is the obturator oblique while testing the hip in flexion, adduction, and internal rotation with axial load applied to the femur.

**Cadaver Pelvic Biomechanical Study: Locked Versus Standard Unlocked Plating of the Symphysis Pubis in a Type C Pelvic Injury Model**

*Christopher P. O'Boynick, MD; Gary Bledsoe, PhD; Berton R. Moed, MD;  
Saint Louis University School of Medicine, Saint Louis, Missouri, USA*

**Purpose:** This is a biomechanical study comparing locked plating of the pubic symphysis with standard unlocked bicortical fixation using a Synthes 3.5-mm six-hole combination locked/nonlocked symphyseal plate in an osteopenic type C pelvic injury model (OTA 61-C1.2). The hypothesis is that there will be no difference in failure rates of the symphyseal fixation between the locking and nonlocking constructs.

**Methods:** After a dual-energy x-ray absorptiometry (DEXA) scan was performed on each of eight cadaver pelvis specimens, sectioning of the pubic symphysis was performed in conjunction with unilateral release of the sacroiliac (SI), sacrospinous and sacrotuberous ligaments, and pelvic floor to simulate a type C pelvic injury. The disrupted SI joint was then reduced and fixed using two Synthes 6.5-mm cannulated screws. Fluoroscopy was used to confirm appropriate reduction and screw placement. Next, a Synthes six-hole 3.5-mm symphysis plate was applied. Four pelvises were fixed with six 3.5-mm locking screws and four pelvises were fixed with six standard 3.5-mm unlocked bicortical screws. Both groups were similar, based on the DEXA scan results ( $P = 0.686$ ). Each pelvis was then mounted on a servohydraulic materials-testing machine in a fashion similar to the "dancing pelvis" model used by Tile et al and were cycled up to 1 million cycles or failure, whichever occurred first.

**Results:** Five specimens experienced failure at the interface between the mounting jig and the S1 vertebral body at between 400,000 and 1 million cycles. Frank failure of the anterior or posterior instrumentation did not occur. There were no differences between the groups with respect to average cycles (0.886) or symphyseal minor widening (0.886).

**Conclusion:** Locked plating has various theoretical advantages when compared to standard plating techniques. However, there appears to be no difference in failure rates between these two constructs in an osteopenic type C pelvic injury model. The results from this study indicate that, in the setting of an acute pelvic ring injury, a traditional and potentially more cost-effective strategy can be employed with similar expectation for success.

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### Risk Factors for the Development of Severe Heterotopic Ossification Following Acetabular Fracture Surgery

*Harris S. Slone, MD; Zeke J. Walton, MD; Charles A. Daly, BS; Russell W. Chapin, MD; William R. Barfield, PhD; Lee R. Leddy, MD; Langdon A. Hartsock, MD; Medical University of South Carolina, Charleston, South Carolina, USA*

**Background/Purpose:** Heterotopic ossification (HO) is well documented in the orthopaedic literature as a known consequence of acetabular fracture fixation. There is evidence in the orthopaedic literature to suggest that more significant HO limits functional outcomes. HO prophylaxis may have untoward side effects and can be very costly, but development of HO can necessitate further surgical intervention. There is little available literature to help delineate which patients who undergo surgical fixation of acetabular fractures are more likely to develop HO, and therefore determine which patients are most likely to benefit from prophylaxis.

**Methods:** Patients who had surgical fixation of acetabular fractures at our institution over a 9-year time period were identified. Demographic data were recorded including age, sex, race, fracture type according to the OTA classification, surgical approach, time from injury to surgery, presence of head injury, and presenting Glasgow Coma Scale. Radiographs were reviewed by a fellowship-trained musculoskeletal radiologist, and HO was noted and classified based on the classification according to Brooker.

**Results:** 460 acetabular fractures underwent surgical fixation in a 9-year period at our institution. 291 of these patients met inclusion and exclusion criteria. 83 patients (29%) were female and 208 (71%) were male. 164 (56.4%) of these patients were Caucasian, 112 (38.5%) were African American (AA), 14 (5%) were Hispanic. 17 patients required subsequent HO excision. Patients with Brooker grade 3 and 4 were considered to have "severe" HO for the purposes of statistical analysis. 71 patients (24%) developed severe HO. 39% of those who developed severe HO were Caucasian, 52% were AA.  $\chi^2$  testing suggests a statistically significant association between severe HO formation and race ( $P = 0.007$ ). 33% of AA patients developed severe HO, compared to 17% of White patients. AA patients had a relative risk (RR) of 1.3 for the development of severe HO when compared to nonAA patients. AA males were most likely to develop severe HO when compared to other race and gender demographics ( $P = 0.005$ ), with an RR of 1.8. Logistic regression showed that race ( $P = 0.005$ ), surgical approach ( $P = 0.003$ ), and trochanteric osteotomy ( $P = 0.007$ ) were predictors of severe HO formation.

**Conclusions:** Our results suggest there is an increased risk for severe HO development in African Americans compared to Caucasians following surgical fixation of acetabular fractures. Additionally, males are at higher risk for the development of severe HO than females. The higher-risk patients identified in this study may benefit from a more aggressive HO prophylaxis regimen.

**Open Pelvic Ring Fractures: What Are the Risk Factors for Mortality and Infection?**

Julie Taylor, BS; Robert V. O'Toole, MD; Theodore T. Manson, MD;  
R Adams Cowley Shock Trauma Center, Department of Orthopaedics,  
University of Maryland School of Medicine, Baltimore, Maryland, USA

**Purpose:** Open pelvic ring fractures have historically been associated with high mortality and infection rates. Our hypothesis was that unstable fracture patterns and perineal wound location would predispose to infection and high mortality, whereas the use of diverting colostomy would protect against infection and death.

**Methods:** We conducted a retrospective study at a single urban Level I trauma center of all patients with open pelvic ring fractures from July 1995 to May 2011. Patients were identified from a prospectively maintained trauma registry and charts were reviewed to assess study variables. 85 patients qualified for inclusion. The mean ISS was 26 and the overall mortality rate was 13%. Diverting colostomies were performed on 39% of the patients. The rate of bladder/urethral injury was 28%. Categorical variables were compared using the Fisher exact test with a *P* value of 0.05 set for significance.

**Results:** For open Young-Burgess anteroposterior compression type 3 (APC3) fractures, the mortality rate (28%) was higher than that for non-APC3 fractures (7%) (*P* = 0.01). There was no relationship found between mortality and the location of the open wound. The mortality rate among those who received a colostomy (24%) was significantly higher than the mortality rate in those who did not receive a colostomy (6%) (*P* = 0.02). In a subgroup analysis of 51 patients who had more complete data and were seen from 2002 to May 2011, 39% had positive bacterial cultures and required return to the operating room for irrigation and débridement. Infection rates were significantly higher in those who received a colostomy (58%) versus those who did not receive a colostomy (28%) (*P* = 0.04). The infection rate in those who sustained a bladder/urethral injury (71%) was higher than that for patients with no bladder injury (27%) (*P* = 0.009). In patients with a perineal wound location, there was a large clinical difference in wound infection rates in patients who had a colostomy (62%) versus patients who did not have a colostomy (25%) but this difference was not statistically significant (*P* = 0.18).

**Conclusion:** In open pelvic ring fracture patients, APC3 fracture pattern is a risk factor for mortality. Colostomy did not seem to be protective against death or infection but this may be a reflection of selection bias towards worse injuries receiving colostomies. Somewhat surprisingly, bladder injury was strongly associated as a risk factor for the development of infection, but wound location did not correlate with infection.

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### Quantitative and Qualitative Assessment of Bone Perfusion and Vascularity in Patellar Fractures Using Gadolinium-Enhanced MRI

Lionel E. Lazaro, MD<sup>1</sup>; David S. Wellman, MD<sup>1</sup>; Peter K. Sculco, MD<sup>1</sup>; Craig E. Klinger, BS<sup>1</sup>; Jonathan Dyke, PhD<sup>2</sup>; Nadine C. Pardee, BS<sup>1</sup>; Thomas W. Axelrad<sup>1</sup>, MD; Marschall B. Berkes<sup>1</sup>, MD; Michael B. Cross<sup>1</sup>, MD; David L. Helfet, MD<sup>1</sup>; Dean G. Lorich, MD<sup>1</sup>;  
<sup>1</sup>Hospital for Special Surgery and Weill Medical College of Cornell University, New York, New York, USA;  
<sup>2</sup>Citigroup Biomedical Imaging Center, Weill Medical College of Cornell University, New York, New York, USA

**Background/Purpose:** Complications and residual anterior knee pain following surgical interventions and trauma about the knee have been hypothesized to develop secondary to disruption of the patellar vascular supply. Previous anatomic studies suggest that the intrinsic vascular arrangement of the patella predisposes the proximal pole to severe ischemic injury following fracture, which itself may be a component of postinjury pain. There is no current consensus in the literature on the patella's primary vascular supply, nor are there reports that quantify the relative contribution of major vessels or the effect of fracture on patellar blood flow. This study aims to define the arterial supply to the patella and evaluate the effect of fracture on patella vascularity.

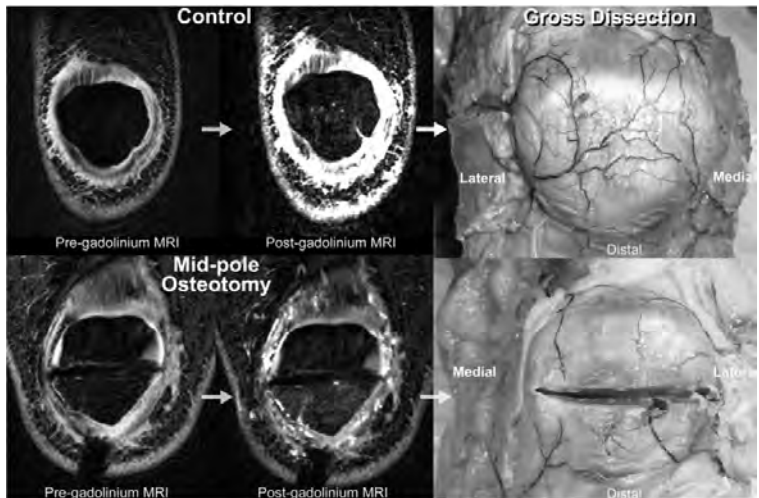
**Methods:** In 40 fresh-frozen cadaver knees (20 matched pairs), the superficial femoral artery, anterior tibialis artery, and posterior tibialis artery were cannulated. One side of each matched pair was randomly chosen to undergo one of two osteotomies simulating different levels of a best-case scenario transverse fracture pattern (simple transverse pattern, minimally displaced, preserved peripatellar anastomotic ring): (1) ten midpole osteotomies (MPOs; figure) and (2) 10 distal pole osteotomies (DPOs). The intact contralateral side of each pair was used as a control. For volumetric analysis, gadolinium (Gd-DPTA) was injected, and enhancement on MRI was compared between pre- and postcontrast imaging as well as between osteotomized patellar bone fragments and the corresponding intact areas on the control side. We then injected a urethane polymer compound and dissected all specimens to examine, photograph, and document extraosseous vascularity findings.

**Results:** MRI analysis showed that the largest vascular contribution to the patella was through an artery entering at the inferior pole in 100% of specimens (80% entering inferomedially). It also revealed an overall decrease in Gd-DPTA enhancement in both transverse osteotomy groups, with a mean loss of -36% contrast enhancement in the proximal fragment (MPO -40%; DPO -31%) and -3% in the distal fragments (MPO -2%; DPO -3%). The MPO group revealed a larger overall reduction in number of vessels penetrating the dorsal cortex (average  $2.7 \pm 1.7$ ;  $P \leq 0.05$ ) and a higher number of disrupted vessels in the prepatellar anastomotic network (average  $3.6 \pm 1.6$ ;  $P \leq 0.05$ ) compared to the DPO group. Enhancement in the superior half of the patella was compared to the inferior half in 10 control specimens; an average 69% ( $P \leq 0.05$ ) greater enhancement was found in the inferior pole.

**Conclusions:** The entire blood supply to the patella arises from the peripatellar anastomotic ring. This study provides quantitative and qualitative data demonstrating that the dominant arterial supply enters the patella through the inferior pole. Every surgical intervention about



the knee should be based on preservation of the peripatellar ring, particularly the inferior patellar network. In the fracture setting, a transverse patella fracture pattern negatively affects blood flow to the proximal fragment, a disruption that may increase risk of articular cartilage deterioration and anterior knee pain. When possible, inferior pole patellectomy should be avoided in order to retain vascularized bone. Understanding the contribution of major patellar blood vessels and the effect of fracture on vascularity can aid in surgical planning, fracture fixation, and patient counseling.



POSTER ABSTRACTS

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### CT Scan Improves Classification and Management of Open Fractures About the Knee Compared to Plain Radiographs in Patients Presenting to the Emergency Department With a Periarticular Knee Wound

*Sanjit R. Konda, MD; Daniel Howard, BS; Roy I. Davidovitch, MD; Kenneth A. Egol, MD; NYU Hospital for Joint Disease, New York, New York, USA*

**Purpose:** The primary goal was to determine the effectiveness of CT scan versus plain radiographs to classify and guide management of open fractures about the knee in patients who presented to the emergency department (ED) with a periarticular knee wound. Secondly, we sought to characterize the injury profile of periarticular knee wounds and their association with fractures about the knee.

**Methods:** An IRB-approved protocol was established to obtain plain radiographs followed by a CT scan of the knee of all patients who presented to the ED with a periarticular knee wound suspicious for a traumatic arthrotomy. We identified 62 patients (63 knees) over a 3-year period who met these criteria. CT images and plain radiographs were reviewed on a picture archiving and communication system (PACS) (Centricity, GE Healthcare). The OTA fracture classification system was used to classify fractures. One of two fellowship-trained orthopaedic trauma surgeons evaluated plain radiographs first and the corresponding CT scan second and recorded a fracture classification and management plan based on each imaging study. CT scan was assumed to be the gold-standard test to diagnose a fracture. We calculated the sensitivity (Sn), specificity (Sp), negative predictive value (NPV), and positive predictive value (PPV) of plain radiographs to detect a fracture. Descriptive statistics were used to compare the effectiveness of plain radiographs versus CT scan to classify and manage a fracture. The Student *t* test was used to calculate differences in mechanism of injury and the association to fractures of the knee.

**Results:** 21 of 63 knees (33%) had an open fracture of the knee and all had intra-articular air indicative of an associated traumatic arthrotomy. Of 32 patients with a traumatic arthrotomy, 63% (21 of 32) had an associated open fracture of the knee. There were 10 tibial, 8 patellar, 4 distal femoral, and 4 nonclassifiable fractures. The Sp/Sn and PPV/NPV of plain radiographs to detect and rule out a fracture were 98%/65% and 94%/82%, respectively. Compared to plain radiographs, CT scan altered the fracture classification in 48% of patients and altered the management plan in 43% of patients. Gunshot wounds (GSW) to the knee had a 68% (13 of 19) incidence of an associated open periarticular and/or intra-articular fracture compared to a 20% incidence for all other injury mechanisms combined (8 of 44) ( $P < 0.001$ ).

**Conclusion:** Patients who present to the ED with a periarticular knee wound have a high incidence of an open fracture (33%) and the incidence is nearly doubled (63%) if a traumatic arthrotomy is present. The probability of an open fracture is significantly increased if the mechanism of injury is a GSW; however, this does not exclude other mechanisms from causing this injury pattern. CT scan improves classification and management of open fractures compared to plain radiographs and should be considered as part of the routine work-up in patients with periarticular knee wounds given the high incidence of fractures.

**Tibial Plateau Fractures With and Without Meniscus Tear:  
Results of a Standardized Treatment Protocol**

*Jordanna Forman, BS; Raj Karia, MPH; Roy I. Davidovitch, MD; Kenneth A. Egol, MD;  
NYU Hospital for Joint Diseases, New York, New York, USA*

**Purpose:** The purpose of this study was to determine what patient and injury factors are associated with the presence of a meniscus tear in patients who sustain tibial plateau fractures. We also sought to compare functional outcome, pain scores, and final range of knee motion between patients who sustain a tibial plateau fracture, with and without meniscal injury.

**Methods:** A total of 99 patients who sustained 101 acute tibial plateau fractures requiring surgery were included in the study cohort. Patients were divided into two groups: those with and without meniscus tears at the time of initial injury. Statistical analysis with the Student *t* test for continuous variables and  $\chi^2$  test for categorical variables was performed to compare those with and without a meniscal tear. All torn menisci were repaired at time of fracture fixation. Logistic regression was performed to identify the variables that predicted the presence of a meniscus tear and repeated analysis of variance (ANOVA) measures were used to assess functional outcome scores.

**Results:** 54 patients with 56 tibial plateau fractures (55%) were found to have an associated meniscal tear. The average amount of joint depression in this group was 12.3 mm (range, 2.0-29.5). The remaining 45 patients with 45 fractures (45%) had an average depression of 5.4 mm (range, 0.0-12.8). Degree of tibial plateau depression was the only significant predictor of meniscal injury. There were no significant differences in the functional outcome, pain scores, and knee range of motion between the groups of fractures with and without meniscus tears at the longest follow-up interval (mean 13 months).

**Conclusions:** Our findings suggest that amount of depression in tibial plateau fractures is a significant predictor of the occurrence of a meniscus tear with an odds ratio of 1.36. These results suggest that acute repair of meniscal injury in association with fracture repair result in functional results similar to those patients who did not sustain a meniscus tear.

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**CT Scan to Detect Traumatic Arthrotomies via Intra-Articular Air in the Knee Joint: A Cadaver Study to Define a Low Radiation Dose Imaging Protocol**

*Sanjit R. Konda, MD; Daniel Howard, BS; Soterios Gyftopoulos, MD; Roy I. Davidovitch, MD; Kenneth A. Egol, MD; NYU Hospital for Joint Disease, New York, New York, USA*

**Purpose:** We have previously shown that CT scan is effective to detect traumatic arthrotomies of the knee joint via intra-articular air. We sought to establish a low radiation dose imaging protocol to detect intra-articular using a cadaver knee model in this OTA-granted study.

**Methods:** We used 10 adult fresh-frozen cadaver knees. A Siemens SOMATOM Sensation 64 CT scanner was used to obtain the CT scans using a 2.0-mm slice thickness from the distal one-third of the femur to the proximal one-third of the tibia. Sagittal and coronal reconstructions were rendered. The baseline radiation dose for a knee (mean = 8.42 mSV) was calculated using the Care Dose setting of the CT scanner (which automatically limits the radiation dose while obtaining the best image quality). We then manually lowered the radiation dose sequentially by approximately half for each subsequent CT scan to the lowest allowable limit of the CT scanner: 4.13 mSV, 2.61 mSV, 1.23 mSV, and 0.74 mSV. Each knee was scanned at each radiation dose with 6 varying amounts of intra-articular air: no air and 0.1 cm<sup>3</sup>, 0.3 cm<sup>3</sup>, 0.5 cm<sup>3</sup>, 0.7 cm<sup>3</sup>, and 0.9 cm<sup>3</sup> of air. Air was introduced into the knee joint into the retropatellar space using an 18-gauge needle and a 3.0-cm<sup>3</sup> syringe. All scans were paired with control scans without air and were read by an attending radiologist (observer 1) and an attending orthopaedic surgeon (observer 2) who were blinded to the presence of intra-articular air. Interobserver reliability was calculated using Cohen's kappa ( $\kappa$ ) coefficient. The Radiation Threshold Dose ( $Rad_{TH}$ ) was defined as the lowest radiation dose at a given amount of intra-articular air for which the  $\kappa$  coefficient for interobserver reliability was greater than or equal to 0.8. We calculated the  $Rad_{TH}$  for 0.1 cm<sup>3</sup>, 0.3 cm<sup>3</sup>, 0.5 cm<sup>3</sup>, 0.7 cm<sup>3</sup>, and 0.9 cm<sup>3</sup> of intra-articular air. We then calculated the sensitivity (Sn) and specificity (Sp) of the CT scan to detect intra-articular air at each  $Rad_{TH}$ .

**Results:** The mean age of the 10 cadaver specimens was  $74.4 \pm 12.6$  and there were 6 males and 4 females. The interobserver reliability  $\kappa$  coefficient was 1.0 for each volume of intra-articular air at each radiation dose. Therefore, the  $Rad_{TH}$  at each volume of intra-articular air was 0.74 mSV. The Sn and Sp of the CT scan to detect intra-articular air at 0.74 mSV was 100% at each volume of intra-articular air.

**Conclusions:** CT scan using a radiation dose of 0.74 mSV is sufficient to detect a minimum of 0.1 cm<sup>3</sup> of intra-articular air. This is approximately 10 $\times$  lower than the standard radiation dose used in the clinical setting. Future studies using CT scan to detect traumatic arthrotomies should consider using this lower radiation dose.

**Knee Arthroplasty Following Tibial Plateau Fracture**

*Matthew T. Houdek, MD<sup>1</sup>; Jordan Smith, MD<sup>2</sup>; William Grana, MD<sup>2</sup>; John T. Ruth MD<sup>2</sup>;*

*<sup>1</sup>Mayo Clinic Department of Orthopedic Surgery, Rochester, Minnesota, USA;*

*<sup>2</sup>University of Arizona Health Network, Tucson, Arizona, USA*

**Purpose:** There is incomplete literature regarding knee arthroplasty following tibial plateau fracture. This study reviews a 10-year experience in the treatment of tibial plateau fractures to identify factors associated with pain, osteoarthritis, and ultimately total knee arthroplasty.

**Methods:** IRB approval was obtained. Charts of all adult patients with a tibial plateau fracture (ICD-9 codes 823.0 and 823.1) at our Level I trauma center over a 10-year period (2000-2010) were reviewed. Fracture fixation was performed by orthopaedic trauma specialists. Fracture analysis was based on the radiographic images and operative reports and radiographic evidence of arthritis was identified by a musculoskeletal radiologist.

**Results:** A total of 486 adult patients sustained 493 operatively treated tibial plateau fractures with 42 patients lost to follow-up. Average follow-up was 25.8 months (range, 0.5-93 months). 29 fractures were associated with compartment syndrome, 55 fractures were open, with 94 fractures having an identified meniscal tear. 41% of the patients complained of pain at the end of follow-up (n = 183). Of the patients who complained of pain, 46% (n = 86) underwent additional surgery to address the complaint, with the majority undergoing hardware removal. Radiographic osteoarthritis (OA) was seen in 156 fractures (34%). 20 patients underwent knee arthroplasty, representing 4.5% of the total population and 13% of the patients with OA. Average time to arthroplasty was 26.8 months (range, 4-96 months). The most common fracture pattern in these patients (n = 7) was OTA 41-B1.2 (Schatzker IV medial condyle), with an overall average initial maximum depression of 5.4 mm. 60% of patients requiring knee arthroplasty had meniscal injury identified at their index procedure. Of those who underwent arthroplasty, the average age was 55.1 years compared to 50.7 years in patients who did not. 18 of the patients were treated with total knee arthroplasty and two patients received medial unicompartmental arthroplasty.

**Conclusion:** Progression to knee arthroplasty in this study of 486 patients occurred infrequently. Internal fixation of tibial plateau fractures resulted in no clinical reports of pain in 59% of patients at final follow-up. Meniscal tear was present at the index procedure in the majority of patients requiring arthroplasty, and a medial condylar fracture pattern was most commonly observed. Osteoarthritis has been associated with persistent pain in previous studies, and was demonstrated in this population to be present almost three times more commonly in patients requiring arthroplasty.

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<b>Factors Associated With Pain</b>	<b>Statistical Significance</b>	<b>Odds Ratio</b>	<b>95% CI of Odds Ratio</b>
Infection following ORIF	0.0001	38.08	5.11-283.7
Presence of osteoarthritis at follow-up	0.0001	4.03	2.67-6.09
Compartment syndrome at time of injury	0.0007	3.80	1.64-8.77
Meniscal tears at time of injury	0.0001	2.95	1.84-4.73
Use of a spanning external fixator prior to definitive fixation	0.0001	2.73	1.75-4.26
Knee instability at follow-up	0.02	2.14	1.10-4.14
Open fracture at initial injury	0.01	2.02	1.14-3.58
Initial tibial plateau depression >7 mm	0.006	1.7	1.16-2.49
High-energy fracture OTA 41-B1.2 and 41-C	0.01	1.63	1.11-2.39
CI, confidence interval; ORIF, open reduction and interval fixation.			

See pages 97 - 144 for financial disclosure information.

**The Use of Calcium Phosphate Bone Cement in Tibial Plateau Fractures:  
A Systematic Review and Meta-Analysis***Sara C. Graves, MD; Yulin Hswen; John Naslund; Natalie Riblet;**Robert V. Cantu, MD; Alexander O. Orem, MD;**Dartmouth Hitchcock Medical Center, Lebanon, New Hampshire, USA*

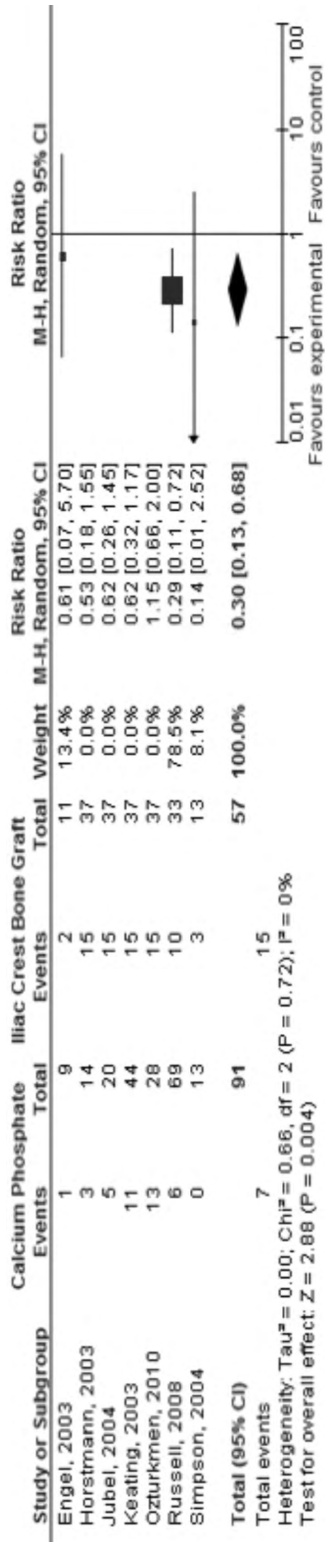
**Background/Purpose:** Orthopaedic surgeons have several options to address metaphyseal defects resulting from tibial plateau fractures including allograft, autologous iliac crest bone graft (ICBG), and calcium phosphate bone cement (CPC). This analysis was conducted to determine whether the use of CPC reduces the rate of subsidence and improves functional outcomes when compared to conventional bone graft for tibial plateau fractures.

**Methods:** The Cochrane Library, MEDLINE, EMBASE, EBSCO CINAHL, Google Scholar, proceedings of several major conferences, clinical trial registries, and bibliographies were searched. Electronic databases were searched from inception to October 2011 with no limits or language restrictions. Comparative studies and case series evaluating the treatment of surgically indicated closed acute tibial plateau fractures using CPC were included if they reported rates of subsidence and had a minimum 6-month follow-up. Two of the authors and one author fluent in German independently extracted data including methodological quality and radiographic and clinical outcomes using a customized data collection tool. Data were pooled using weighted mean difference and relative risks (RR).

**Results:** Of the 47 records identified, 7 studies met the inclusion criteria (1 randomized controlled trial, 2 cohort studies, and 4 case series), which included 225 fractures treated with CPC and 62 fractures treated with ICBG. The rate of subsidence was 70% less in the CPC group than in the control groups (RR 0.30,  $P = 0.004$ ,  $I^2 = 0\%$ ). A forest plot is shown in the figure below. There was no quantitative difference in clinical scores or complication rates between the two groups, although there appeared to be a trend toward lower adverse events in the CPC group.

**Conclusions:** Although there are relatively few comparative studies in the literature and no studies comparing CPC to allograft, CPC had lower rates of subsidence or loss of reduction and appeared to have similar or better functional outcomes and rates of adverse outcomes when compared to ICBG.

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**Figure**

Forest plot for RR of subsidence (defined as >2 mm) including only the three comparative studies in the summary estimate.



**The Saline Load Test Redefined: A Test to Detect Traumatic Arthrotomies and Rule Out Periarticular Wounds Equivalent to No Traumatic Arthrotomy of the Knee**

*Sanjit R. Konda, MD; Roy I. Davidovitch, MD; Kenneth A. Egol, MD;  
NYU Hospital for Joint Disease, New York, New York, USA*

**Purpose:** This review was undertaken to describe the use of the Saline Load Test (SLT) to diagnose traumatic knee arthrotomies utilizing a new definition that more adequately characterizes its use in the emergency department (ED) setting.

**Methods:** We retrospectively reviewed all patients who underwent an SLT to diagnose a traumatic knee arthrotomy over a 3-year period at a Level I trauma center and who had a minimum of 10 days follow-up. We identified 50 patients who met these criteria. A positive traumatic arthrotomy of the knee (+TAK) was defined as: (1) operating room (OR) confirmation of an arthrotomy or (2) a negative SLT (-SLT) with follow-up revealing a septic knee. A periarticular wound equivalent to no traumatic arthrotomy of the knee (pw = [-TAK]) was defined as: (1) OR evaluation revealing no arthrotomy or (2) -SLT with follow-up revealing no septic knee. Per protocol, all patients with -SLT were discharged from the ED on a 7-day course of prophylactic antibiotics and all patients with a +SLT were taken to the OR for operative irrigation and débridement of the wound and placed on a 2-day course of IV antibiotics. We calculated the sensitivity (Sn) and specificity (Sp) of the SLT to detect traumatic arthrotomies and rule out periarticular wounds equivalent to no traumatic arthrotomy.

**Results:** There were 34 males and 16 females with a mean age of  $31.1 \pm 17.8$  years. The most common mechanisms of injury were from gunshot wounds and falls in 14 patients each, followed by vehicular accidents in 9 patients. Various other mechanisms of injury accounted for the remaining 13 patients. The mean wound size was  $3.9 \pm 4.3$  cm and the mean saline load volume was  $74.9 \pm 28.2$  cm. The mean time for follow-up evaluation for patients with a -SLT and a +SLT was  $34.5 \pm 67.6$  days and  $25.8 \pm 21.9$  days, respectively. There were 19 +SLTs of which there were 16 +TAK and 3 pw = (-TAK). There were 31 -SLTs of which there were 1 +TAK and 30 pw = (-TAK). No patients at follow-up had a septic knee. The SLT has a sensitivity of 94% and a specificity of 91% for detecting +TAK and ruling out pw = (-TAK). The false-positive rate of the SLT to detect +TAK is 6%.

**Conclusions:** Using +TAK and pw = (-TAK) as the newly defined measures of the SLT, we are able report the sensitivity (94%) and specificity (91%) of the SLT in the ED setting while still maintaining the clinical relevancy of the test. A high false-positive rate suggests that other diagnostic tests should be considered in evaluating traumatic knee arthrotomies.

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**Tibial Plateau Fractures Treated With Structural Bone Grafts Experience Minimal Articular Subsidence and Good Clinical Outcomes**

*Marschall B. Berkes, MD; Milton T. M. Little, MD; Patrick C. Schottel, MD; Nadine C. Pardee, BS; Aernout Zuiderbaan; Lionel E. Lazaro; Dean G. Lorich, MD; David L. Helfet, MD; Hospital for Special Surgery, New York, New York, USA*

**Purpose/Hypothesis:** A variety of nonstructural bone grafts, including calcium phosphate cement and cancellous autograft, have been used to fill bone voids in tibial plateau fractures in order to prevent articular subsidence. Structural bone grafts, such as Plexur P (Osteotech) and fibula cortical allograft, possess material properties that these nonstructural grafts do not and may better assist in achieving an anatomic reduction and preventing articular subsidence. The purpose of this study is to report the rate of anatomic reduction and articular subsidence, as well as clinical outcomes for tibial plateau fractures treated with Plexur and fibula allograft. We hypothesize these fractures will have low rates of malreduction and subsidence, with good clinical outcomes.

**Methods:** A trauma registry was used to identify tibial plateau fractures treated with open reduction and internal fixation and structural bone graft (either Plexur P or fibular allograft). Medical records were reviewed to identify patient comorbidities, injury variables, operative data, and information regarding clinical follow-up. Immediate postoperative and final follow-up AP and lateral radiographs were examined to determine the amount of articular subsidence that occurred (primary outcome). Secondary outcomes included the rate of fracture malreduction greater than 2 mm and clinical outcomes including the Knee Outcome Survey Activities of Daily Living Scale (KOSADLS), the Lower Extremity Functional Scale (LEFS), and the Short Form-36 (SF-36). Outcomes were compared between Plexur P and fibular allograft. Additionally, these results were pooled and compared to quoted rates of subsidence in the literature using nonstructural bone grafts (Russell et al).

**Results:** 84 tibial plateau fractures were treated with structural bone grafts (31 Plexur P, 53 fibula). The average measured amount of articular subsidence was 0.1 mm; no patients experienced subsidence >2 mm. This rate was significantly lower when compared to previously stated rates for autogenous iliac crest (30.3%,  $P < 0.0001$ ) and calcium phosphate cement (8.7%,  $P = 0.0074$ ). The rate of fracture malreduction was 11.9% (10 of 84); among these cases, only three had more than 3 mm of residual incongruity. Average outcome scores for the entire cohort were KOSADLS 81.5, LEFS 78.6, SF-36 physical component 48.2, mental component 53.3. There was no difference between the Plexur P and fibula groups with regards to the primary or secondary outcomes.

**Conclusions:** The use of structural bone graft resulted in a high rate of anatomic reduction and negligible rate of articular subsidence and good clinical outcomes in the treatment of this population of tibial plateau fractures. This compares favorably to historical results using nonstructural grafts. A study directly comparing the efficacy of these structural grafts to nonstructural grafts, including calcium phosphate cement, is warranted.

**Diagnostic Accuracy and Reproducibility of the Ottawa Knee Rule (OKR) Versus the Pittsburgh Decision Rule (PDR)**

*Tung C. Cheung, MD; Robert J. Derksen, MD; Yeliz Tank, BS; Wim E. Tuinebreijer, MD; Roelf S. Breederveld, MD; Red Cross Hospital, Beverwijk, The Netherlands*

**Purpose:** This study was undertaken to validate diagnostic accuracy of two clinical decision rules, the Ottawa Knee Rule (OKR) and the Pittsburgh Decision Rule (PDR), developed for selective use of radiographs in the evaluation of isolated knee trauma, and to compare reproducibility of the two clinical decision rules. Application of the rules may lead to a more efficient evaluation of knee injuries and a reduction in healthcare costs without an increase in missed fractures.

**Methods:** A cross-sectional interobserver agreement study was conducted in the emergency department of a general hospital from October 2008 to July 2009. Two observers, emergency medicine residents and surgical residents, collected data on standardized data forms. Standard knee radiographs were performed in each patient. Participants were patients older than 18 years with isolated knee injuries occurring less than 7 days previously. Pooled sensitivity and specificity were compared using  $\chi^2$  statistics and interobserver agreement was calculated by using kappa ( $\kappa$ ) statistics.

**Results:** 90 injuries were assessed. Seven injuries (7.8%) concerned fractures. For the OKR, the pooled sensitivity and specificity were 0.86 (95% confidence interval [CI], 0.57-0.98) and 0.27 (95% CI, 0.21-0.35), respectively. The PDR had a pooled sensitivity and specificity of 0.86 (95% CI, 0.57-0.98) and 0.51 (95% CI, 0.43-0.59), respectively. The PDR was significantly ( $P = 0.002$ ) more specific. The  $\kappa$  values for the OKR and PDR were 0.51 (95% CI, 0.32-0.71) and 0.71 (95% CI, 0.57-0.86), respectively.

**Conclusion:** The PDR was found to be more specific than the OKR, with equal sensitivity. Interobserver agreement was moderate for the OKR and substantial for the PDR.

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### **A Modified Posterior Approach to the Knee for Posteromedial Tibial Plateau Fracture Fixation**

*Reshid Berber, MBBS; Charlotte P. Lewis; Daren P. Forward, MD; Christopher G. Moran, MD; Queen's Medical Centre, Nottingham University Hospitals, Nottingham, United Kingdom*

**Background/Purpose:** The purpose of this study is to demonstrate the utility of a modified posteromedial surgical approach to the knee in treating a series of patients with complex tibial plateau injuries with associated posteromedial shear fractures. Posteromedial shear fractures are often underappreciated and their clinical relevance has recently been characterized. Less-invasive surgery and indirect reduction techniques are known to be inadequate for treating these posteromedial coronal plane fractures. We report a case series and cadaveric dissection highlighting the relevant anatomy.

**Methods:** The approach includes an inverted L-shaped incision and reflection of the medial head of gastrocnemius, while protecting the neurovascular structures. This is a more extensile exposure than described by Trickey (1968). Our case series includes 8 females and 8 males. The average age is 53.1 years. The mechanism of injury included 7 road traffic accidents, 5 falls from height, 1 industrial accident, and 3 valgus injuries. All patients were 41-B3 or 41-C-type fractures with a posteromedial split depression. Two were open, two had vascular compromise, and one had neurologic injury.

**Results:** Average time to surgery was 6.4 days (range, 0-12). Seven patients were fixed using the posteromedial approach alone and three were combined with an anterior approach. Average operative time was 142 minutes (range, 76-300). Average length of stay was 17.3 days (range, 7-46). Two patients suffered reduced range of movement requiring manipulation and physiotherapy, and three patients had a persistent extensor lag of 5°. Two patients developed superficial wound infections treated with antibiotics alone. Anatomic reduction and fracture union was achieved in 13 patients; of the remaining 3 patients, 2 had unavoidable comminution along the articular surface, and 1 suffered anteromedial collapse leading to varus deformity.

**Conclusions:** These are complex fractures to fix, with the best chance for a good outcome achieved by anatomic reduction. We recommend this modified approach, which simplifies the fixation of the fracture by providing excellent exposure and minimal risk.

## Does Anteroinferior Fixation of Midshaft Clavicle Fractures Have a Lower Rate of Hardware Removal and Complications? A Multicenter Retrospective Study

Peter A. Cole, MD<sup>1</sup>; Clifford B. Jones, MD, FACS<sup>2</sup>; Aaron R. Jacobson, DC<sup>1</sup>;

Alex Gilde, BS<sup>2</sup>; Jerald R. Westberg, BA<sup>3</sup>; Andrew H. Schmidt, MD<sup>3</sup>;

<sup>1</sup>University of Minnesota–Regions Hospital, St. Paul, Minnesota, USA;

<sup>2</sup>Michigan State University, Orthopaedic Associates of Michigan, Grand Rapids, Michigan, USA;

<sup>3</sup>Hennepin County Medical Center, Minneapolis, Minnesota, USA

**Background/Purpose:** Recent publications suggest that surgical management of displaced midshaft clavicle fractures may result in improved patient outcomes relative to nonoperative management. Like all interventions, however, this procedure carries known risks. One risk is hardware-related symptoms requiring a secondary surgical procedure. While the rate of hardware removal (HWR) varies, it has been reported to be as high as 50% in some series. As a result, there has been considerable interest in developing new approaches to decrease this morbidity. One technique described is anteroinferior plating of clavicles. In addition to offering a safe trajectory of screw placement, anteroinferior plate placement is thought to reduce plate prominence, which could potentially reduce the rate of hardware removal. The primary objective of this study was to compare HWR rates with plates positioned superiorly to those positioned anteroinferiorly. Secondary objectives were to report any significant correlation between HWR, complications demographics, fracture characteristics, or implant types and superior versus anteroinferior plating.

**Methods:** A retrospective study of 328 consecutive midshaft (15.B1, B2, B3) clavicle fractures treated by open reduction and internal fixation at three Level I trauma centers between 2006 and 2010 was performed. All distal (15.C) and proximal (15.A) fractures were excluded. In addition, any midshaft fractures in which dual plate fixation was utilized were excluded. Electronic medical records and radiographic studies were reviewed to collect patient demographics, injury characteristics, operative techniques, and outcomes.

**Results:** Of the 328 fractures, the rates of hardware failure, nonunion, and infection were 2.7%, 1.5%, and 0.9%, respectively. Plate location, type, and size did not have an effect on nonunion or infection rate; however, there was a higher rate of hardware failure in patients with 2.7-mm plates compared to 3.5-mm (4.7% vs 1.1%). This difference demonstrated a statistical trend ( $P = 0.08$ ). HWR was performed on 42 of 328 patients (12.8%). Reasons for removal included symptomatic hardware (76%), nonunion (9.5%), hardware failure (4.7%), cultural preference (4.7%), and infection (2.3%). Analysis comparing patients requiring HWR to those not requiring revealed both females and fractures classified as 15.B1 had a statistically higher rate of HWR ( $P < 0.001$  and  $P < 0.05$ , respectively). There was no statistical difference for age, body mass index, or tobacco use. 205 fractures (62.5%) were plated anteroinferiorly and 123 (37.5%) superiorly. Comparative analysis of anteroinferior plating and superior plating showed that HWR rates were not statistically significantly different than the anteroinferior group (14.1% vs 10.7%).

**Conclusion:** This study does not provide compelling evidence that either plate location is superior in terms of reducing rates of HWR or complications. Surgeon experience should guide operative decision making, balancing the mechanical and biologic solution for each individual fracture.

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### **Locked Bridge Plating is a Suitable Option for Forearm Fractures Secondary to Civilian Low-Velocity Gunshot Injuries**

*Rahul Vaidya, MD; Anil Sethi, MD; Bryant W. Oliphant, MD; William Braaksma, MD; Nathan Rimmke, MD; Robert Colen, DO; Detroit Receiving Hospital, Detroit, Michigan, USA*

**Purpose:** The purpose of this study is to present the outcomes in patients of low-velocity gunshot fractures of the forearm treated with locked bridge plating and compare it to patients treated with formal débridement and plating.

**Methods:** An IRB-approved retrospective review of 65 consecutive patients with displaced/ comminuted fractures of the forearm secondary to gunshot injuries was carried out. There were 62 males and 3 females with an average age of 27.7 years (range, 16-48). Treatment included a minimum of 48 hours of prophylactic intravenous antibiotics in all patients. 30 patients had their fractures stabilized using a locked bridge plate. These patients had minimal débridement of the gunshot wounds with excision of only frankly necrotic tissue. Bone grafting was not employed in any patient. The remaining 35 patients had a formal irrigation and débridement of the wounds with surgical stabilization using plating with bone grafting in 9 patients. There were 31 isolated radius fractures, 28 isolated ulna fractures, and 6 both-bone fractures of the forearm. 14 patients presented with nerve damage, 7 patients presented with a vascular injury, and 2 patients presented with both. One patient developed a compartment syndrome requiring fasciotomy. 29 patients suffered multiple gunshot wounds with multiple injuries. Nine patients underwent exploratory laparotomy and four a thoracotomy.

**Results:** 58 patients managed operatively required only 1 forearm surgery while 7 patients required multiple surgeries for soft-tissue management. All patients in the latter group were treated with formal débridement and plating. 29 patients treated with locked bridge plating displayed fracture healing at their latest follow-up and 1 patient required revision surgery for delayed union. There were no signs of infection or osteomyelitis at final follow up. All patients of irrigation and débridement with plating showed clinical and radiographic evidence of healing at final follow-up.

**Conclusion:** Forearm fractures caused by low-velocity gunshot wounds in a civilian setting are commonly comminuted single-bone injuries, occasionally associated with nerve and vessel damage. Treatment with locked bridge plating and minimal débridement resulted in a high rate of union and low infection rate. Only one patient required a second surgical procedure. These results suggest that locked bridge plating with minimal débridement is a suitable option for the treatment of forearm fractures following low-velocity gunshot injuries.

**Total Elbow Arthroplasty for Distal Humerus Fractures: Long-Term Outcomes***Philipp N. Streubel, MD; Juan P. Simone, MD; Bernard F. Morrey, MD;**Joaquin Sanchez-Sotelo, MD, PhD;**Mayo Clinic, Rochester, Minnesota, USA*

**Purpose:** Studies on midterm outcomes after total elbow arthroplasty (TEA) for the treatment of complex distal humerus fractures have shown encouraging results. However, long-term results have to date not been published. The purpose of the present study is to analyze outcomes after a minimum 10 years of follow-up of distal humerus fractures treated with primary TEA.

**Methods:** After IRB approval, our institutional joint registry was searched for patients who had undergone primary TEA for an acute nontumoral distal humerus fracture between 1982 and 2001. Radiographs and patient charts were reviewed to confirm data on patient function, radiographic outcomes, and type of revision surgery. Of a total of 659 acute distal humerus fractures admitted to our institution during the study period, 40 had undergone TEA using the Coonrad-Morrey prosthesis (mean age 70 years; range, 38-93).

**Results:** At a minimum 10-year follow-up 19 patients (mean age at surgery 79 years; range, 48-93) had died at a mean 4 years after surgery (range, 2 weeks to 8 years). Of these patients one developed an acute deep infection requiring débridement and irrigation and one had painful hardware that required removal. The remaining 21 patients (mean age 64 years; range, 38-83) had an average follow-up of 15 years (range, 10-19). Of these, 8 patients required revision surgery at an average 9.8 years after initial surgery (range, 1 month to 19 years) for the following reasons: infection in 2, osteolysis in 2, aseptic loosening in 2, and distal component failure in 2. Two revisions were required within 1 month, 1 between 1 month and 1 year, 0 from 1 to 10 years, 3 from 10 to 15 years, and 2 after 15 years or more after surgery. Revision rates for any mode of failure at 10 years were 14%.

**Conclusions:** Total elbow arthroplasty remains a viable option for the management of complex distal humerus fractures in adequately selected patients.

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### The Validation of a New Radiographic Union Score (RUS) for Distal Radius Fractures

Emil H. Schemitsch, MD<sup>1,2</sup>; Anthony Marchie<sup>1</sup>; Alfonso Marchie<sup>3</sup>; Farid Guirguis<sup>4</sup>; Kevin Ho<sup>3</sup>; Martin Roscoe<sup>4</sup>; Anr ElMaraghy<sup>4</sup>; Rad Zdero<sup>2,5</sup>;

<sup>1</sup>Division of Orthopaedic Surgery, University of Toronto, Toronto, Ontario, Canada;

<sup>2</sup>Biomechanics Laboratory, St. Michael's Hospital, Toronto, Ontario, Canada;

<sup>3</sup>Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada;

<sup>4</sup>Division of Orthopaedic Surgery, St. Joseph's Health Centre, Toronto, Ontario, Canada;

<sup>5</sup>Department of Mechanical and Industrial Engineering, Ryerson University, Toronto, Ontario, Canada

**Purpose:** Although various methods of defining fracture healing exist, none have been developed for evaluating union in metaphyseal fractures. This investigation examined the inter- and intraobserver variation in the assessment of union of distal radius fractures by clinicians of varying orthopaedic expertise using a newly developed score.

**Methods:** Radiographs of 102 patients were seen from May 2004 to January 2007 at various stages of healing of distal radius fractures with a wide range of severity. They were independently assessed on two separate occasions, 4 weeks apart. For each radiograph, a score for our newly developed Radiographic Union Score (RUS) for distal radius fractures was given by observers who evaluated the degree of union, quality of callus, number of cortices bridged by callus, overall fracture healing, and the RUS for Tibial fractures (RUST) previously developed by some of us.

**Results:** The chance-adjusted kappa ( $\kappa$ ) statistic, which is a measure of the agreement between observers, was determined as follows (Table 1): union scale developed by Hammer et al (0.29); overall fracture healing (0.37); quality of callus (0.32); number of cortices bridged (0.32); RUS score (0.46). The intraobserver agreement for the RUS was 0.69 (Table 2). Spearman correlation coefficients between the scores of overall fracture healing and RUS, and between the number of cortices bridged and RUS, were 0.91 ( $P < 0.05$ ) and 0.88 ( $P < 0.05$ ), respectively.

**Conclusions:** This investigation presents the first score that permits surgeons to grade metaphyseal fracture union radiographically. This new RUS is a simple and reliable instrument for assessing the healing of distal radius fractures.

**Table 1** Overall interobserver weighted  $\kappa$  values for the RUS

Assessment	Overall Weighted Kappa	95% Confidence Interval
Hammer scale	0.29	0.23 to 0.35
Overall fracture healing	0.37	0.26 to 0.48
Quality of callus formation	0.32	0.25 to 0.39
Number of cortices bridged	0.32	0.23 to 0.41
RUST	0.46	0.31 to 0.61

See pages 97 - 144 for financial disclosure information.



**Table 2** Overall intraobserver weighted  $\kappa$  values for the RUS

Assessment	Overall Weighted Kappa	95% Confidence Interval
RUS	0.69	0.52 to 0.86

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**Exposure of the Distal Humerus Using a Triceps Hemi-Peel Approach**

*Brian F. Grogan, MD, CPT<sup>1</sup>; James A. Blair, MD, CPT<sup>1</sup>; Robert E. Blease, MD, MAJ<sup>2</sup>; Mickey S. Cho, MD, LTC<sup>1</sup>; Joseph R. Hsu, MD, LTC<sup>3</sup>;*

*<sup>1</sup>Department of Orthopedics and Rehabilitation, San Antonio Military Medical Center (SAMMC), San Antonio Uniformed Services Health Education Consortium (SAUSHEC), Fort Sam Houston, Texas, USA;*

*<sup>2</sup>United States Army Tropic Test Center/Ryder Trauma Center, Miami, Florida, USA;*

*<sup>3</sup>US Army Institute of Surgical Research, San Antonio Military Medical Center (SAMMC), San Antonio Uniformed Services Health Education Consortium (SAUSHEC), Fort Sam Houston, Texas, USA*

**Background/Purpose:** Anatomic reduction and fixation of displaced intra-articular distal humerus fractures (OTA 13-B and 13-C) requires adequate visualization of the articular surface. Commonly used surgical approaches involve olecranon osteotomy or reflection of the entire triceps osteoperiosteal insertion. Complications of olecranon osteotomy include nonunion of the osteotomy site, heterotopic ossification, and fixation failure, while reflection of the triceps is associated with extensor mechanism weakness. The previously described triceps–flexor carpi ulnaris (TRIFCU) approach involves reflection of the triceps osteoperiosteal sleeve from the proximal ulna in a lateral to medial direction to exposure the distal humerus articular surface. A novel “hemi-peel” modification of the TRIFCU limits the dissection to 50% of the triceps insertion and avoids complete reflection of the extensor mechanism. This study evaluates the exposure of the distal humerus articular surface obtained using a triceps hemi-peel approach compared with the TRIFCU approach. We hypothesized that the hemi-peel approach would provide equivalent visualization of five designated anatomic landmarks when compared with the TRIFCU approach.

**Methods:** 15 fresh-frozen cadaveric upper extremity forequarter specimens were dissected using a novel lateral to medial “hemi-peel” modification of the TRIFCU approach to the elbow. After completing the hemi-peel exposure, the visible border of the articular surface was marked with a permanent ink pen. The dissection was continued to complete a standard TRIFCU approach, and the visible border of the exposure was again marked. The area between the marked borders of the hemi-peel and TRIFCU approaches was inked with a permanent pen. A calibrated, digital axial photograph of the distal humeral articular surface was taken. The images were analyzed using Image J (NIH) software to quantify the inked area representing the difference in visible trochlear articular surface area exposed by the hemi-peel and TRIFCU approaches. During both approaches, the surgeons’ ability to visualize five predetermined anatomic landmarks was recorded.

**Results:** The TRIFCU exposed an average of 0.888 cm<sup>2</sup> more of the trochlear articular surface than the hemi-peel approach. There was no difference in the ability to identify five designated anatomic landmarks using a hemi-peel or TRIFCU approach. Both approaches allowed visualization of the intertrochlear groove, medial crista posterior crest, and posterior capitulum. The medial crista anterior crest and anterior capitulum were not visible on either approach.

**Conclusion:** The hemi-peel and TRIFCU approach to the elbow allow equivalent visualization of the intertrochlear groove, medial crista posterior crest, and posterior capitulum. Neither approach exposed the medial crista anterior crest and anterior capitulum. The TRIFCU exposed 0.888 cm<sup>2</sup> of the trochlear articular surface, but required complete reflection of the triceps osteoperiosteal insertion. The hemi-peel exposure is a useful approach for the accurate reduction and fixation of displaced intra-articular distal humerus fractures. Further clinical research evaluating and comparing the complication rates and functional outcomes of the hemi-peel and TRIFCU approaches is warranted.

**Disclaimer:** The opinions and assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the Department of the Army or Department of Defense.

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**Heterotopic Ossification in Open Periarticular Combat-Related Elbow Fractures**

*LT Kevin W. Wilson, MD, MC, USN; CPT Jonathan F. Dickens, MD, MC;*

*LT Scott M. Tintle, MD, MC, USN; LT Reed Heckert, MD, MC, USN;*

*CDR John J. Keeling, MD, MC, USN; LTC Romney C. Andersen, MD, MC, USN;*

*MAJ Benjamin K. Potter, MD, MC, USA*

*Department of Orthopaedics and Rehabilitation, Walter Reed National Military Medical Center, Bethesda, Maryland, USA*

**Purpose:** Little is known about heterotopic ossification (HO) in relation to high-energy open periarticular elbow fractures. The purpose of this study is to characterize potential risk factors in the development of HO and review the results of HO resection in a subset of these injuries.

**Methods:** All patients treated for a combat-related open elbow fracture sustained between 2004 to 2011 were retrospectively reviewed. Potential risk factors for development of HO were analyzed, and the outcomes and complications of HO resections were reviewed.

**Results:** After a mean follow-up of 23 months, HO developed in 92 elbows (69.7%) out of 132 consecutive fractures in 128 male patients (average age was 26 years). The mechanism of injury was most commonly explosive blasts (85%, 112 of 132). 41% of patients (54 of 132) were diagnosed with mild traumatic brain injury (TBI), while an additional 24 patients (18%) were transferred with known closed or penetrating head injuries. Two injuries (1.5%) were classified as Gustilo-Anderson type I, 34 injuries (25.7%) were classified as Gustilo-Anderson type II, 51 (38.6%) were III-A, 27 (20.5%) were III-B, and 18 (13.6%) were III-C. 90 patients (68%) were treated with primary prophylaxis of HO, but no significant protective effect could be established. Infection and nerve injury was not found to play a role. The development of HO was significantly associated with the presence of TBI, intra-articular fracture, vascular injury, and soft-tissue injury requiring free-tissue transfer. HO resection was performed on 34 elbows with a mean sustained gain of 49° of flexion-extension range of motion. These resections were complicated by one intraoperative distal humerus fracture, two vascular injuries, one episode of recurrent arthrofibrosis, and one reinjury of a previously injured posterior interosseous nerve.

**Discussion/Conclusion:** In the largest series of open elbow fractures to date, we found a higher rate of HO formation than seen in civilian literature. TBI, intra-articular fracture, vascular injury, and need for flap are potential risk factors. Resection of HO reliably resulted in sustained improvements in functional range of motion; however, these excisions are complex procedures with a moderate rate of major complications.

**Functional Outcomes Following Major Upper Limb Trauma in the Military***The METALS Study Group;**Brown University Department of Orthopaedic Surgery, Providence, Rhode Island, USA*

**Purpose:** This study was undertaken to examine outcomes following major upper limb trauma resulting from high-energy blast/ordnance-related mechanisms and to compare outcomes for those undergoing amputation or limb salvage. We hypothesized that outcomes would be better for limb salvage patients.

**Methods:** This is a retrospective cohort study of 155 US service members who sustained a major upper limb injury while serving in Afghanistan or Iraq. Major limb trauma was defined as resulting in a major amputation (at or proximal to the radiocarpal joint) or requiring reconstruction surgery and either revascularization, bone grafting/bone transport, local/free flap coverage, repair of major nerve injury, or complete compartment injury/compartment syndrome. Participants were interviewed (mean 37.3 months postinjury) and medical records abstracted. The Short Musculoskeletal Function Assessment (SMFA) was used to measure overall function. Additional batteries were used to assess depressive symptoms (Center for Epidemiological Studies Depression Scale), posttraumatic stress (Military Version of the PTSD [Posttraumatic Stress Disorder] Checklist), chronic pain (Chronic Pain Grade Scale), and participation in vigorous sports (Paffenbarger Activity Scale). Differences in outcomes were compared using regression analysis adjusting for age, time to interview, military rank, lower limb injury, social support, and combat experiences (Combat Experiences Questionnaire).

**Results:** Overall, participants report moderate to high levels of disability. 40% have depressive symptoms and 19% screen positive for posttraumatic stress. 18% report pain that interferes with activity and 36% were not working, on active duty, or going to school at follow-up. Mean SMFA scores are shown for 4 groups defined by unilateral versus bilateral major upper limb injury and whether the injury resulted in amputation (AMP) or limb salvage (SAL). Approximately one-third of participants also sustained a major injury to their lower limbs. Removing these individuals from the analysis resulted in similar outcomes (except for SMFA mobility). After adjusting for covariates, there were no significant differences in SMFA or percent with symptoms of depression or PTSD when patients with or without amputation are compared. Significant correlates of outcome included age, time since injury, military rank, intensity of combat experiences, and social support.

**Conclusion:** Major upper limb trauma sustained in the military results in significant long-term disability. These outcomes are similar for those undergoing amputation or limb salvage. There is a need for ongoing improvements in treatment and support to more fully return these casualties with severe upper extremity injury to optimal function.

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Mean SMFA (Population Norm)	Unilateral Injuries		Bilateral Injuries	
	SAL (n = 104)	AMP (n = 33)	Both SAL (n = 11)	SAL ± AMP (n = 7)
Total (12.7)	27.4	24.0	28.9	29.4
Hand/arm (6.0)	20.1	23.5	24.7	34.8
Mobility (13.6)	21.9	14.2	22.4	8.7
Daily activities (11.8)	24.7	23.4	32.7	30.7
Emotional (20.5)	46.4	38.2	36.7	47.9

### Fractures of the Greater Tuberosity of the Humerus: A Retrospective Study on Function, Muscular Atrophy, and Fracture Morphology

Jennifer Mutch, MD<sup>1</sup>; Luojun Wang<sup>2</sup>; George-Yves Laflamme, MD, FRCSC<sup>1</sup>;

Nicola Hagemeister<sup>3</sup>; Dominique M. Rouleau, MD, MSc, FRCSC<sup>1</sup>;

<sup>1</sup>Hôpital du Sacré-Cœur de Montréal, Université de Montréal, Montreal, Quebec, Canada;

<sup>2</sup>Université de Montréal, Montreal, Quebec, Canada;

<sup>3</sup>Centre Hospitalier de l'Université de Montréal, École de Technologie Supérieure, Montreal, Quebec, Canada

**Purpose:** 3% of upper extremity fractures occur in the proximal humerus and occur in both young and aging populations. Previous studies have demonstrated that as little as 2 mm of superior displacement of isolated greater tuberosity fractures significantly increases the force required for abduction and leads to subacromial impingement. This study describes the effect of fracture type, rotator cuff integrity, and muscular atrophy on function, range of motion, strength, and quality of life after greater tuberosity fracture.

**Methods:** A retrospective review of all cases of isolated greater tuberosity fractures (excluding Hill Sachs lesions) seen at a single Level I trauma center from 2006 until December 2010 was performed. 139 cases were identified and 50 patients were invited to participate in the study. Patient data were collected including age, sex, smoking status, dominance, side of injury, mechanism of injury, and treatment received. The Quick DASH (Disabilities of the Arm, Shoulder and Hand), Constant, Pain score, WORC (Western Ontario Rotator Cuff Index), and Short Form 12 v2 questionnaires were completed and a physical examination was performed by a single experienced physiotherapist. Initial and follow-up radiographs were used to classify the fractures according to the Neer, AO, and a new morphologic classification and to measure displacement in millimeters in the cranio/caudal and AP planes. A shoulder ultrasound was performed on all patients by a single musculoskeletal radiologist. Statistical analysis was performed using SPSS software (SPSS v.19, IBM).

**Results:** The recruited patients had an average age of 58 (range, 32-92) and 45% were male. The average WORC score following greater tuberosity fracture was 446, or 79% of expected. Patients who underwent surgical treatment had a tendency towards worse WORC scores (386 surgical vs 262 conservative) but this was not statistically significant. There was also a trend for patients with avulsion type fractures to report more persistent pain at final follow-up. The ultrasound examinations showed significant abnormalities. 66% of the patients had at least one partial tear. 14% of patients had full-thickness tears and this was significantly correlated with initial fracture displacement ( $P < 0.05$ ) and negative outcome ( $P < 0.005$ ). 53% of all patients had evidence of subacromial impingement, including 68% of patients under the age of 50. This was independent of fracture displacement or treatment.

**Conclusion:** This study describes the functional impact of fracture type and rotator cuff pathology associated with isolated greater tuberosity fractures of the proximal humerus. This fracture has a significant impact on shoulder function and is associated with numerous abnormalities on ultrasound examination at final follow-up. Patients with persistent pain following isolated greater tuberosity fractures may benefit from additional imaging to evaluate for associated rotator cuff injuries or impingement syndromes.

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**Fixation Utilizing an Endosteal Strut Augment Allows for Similar Outcomes Between Neer 2, 3, and 4-Part Proximal Humerus Fractures***Marshall B. Berkes, MD; Milton T. M. Little, MD; Nadine C. Pardee, BS;**Patrick C. Schottel, MD; Lauren E. Lamont, MD; Lionel E. Lazaro, MD;**David L. Helfet, MD; Dean G. Lorich, MD;**Hospital for Special Surgery, New York, New York, USA*

**Purpose/Hypothesis:** Prior studies of proximal humerus fractures treated with open reduction and internal fixation (ORIF) have demonstrated a correlation between the number of parts according to the Neer classification and worsening clinical outcomes, with 4-part fractures faring the worst. Recent investigations have demonstrated the value of an endosteal strut augment in terms of enhancing fixation and limiting complications when treating these fractures. We hypothesize that fractures treated with an endosteal augment will experience uniformly good results, regardless of Neer classification.

**Methods:** A prospective database of 143 proximal humerus fractures treated with ORIF using a lateral locking plate and an endosteal strut augment by a single surgeon were retrospectively evaluated. Injury radiograph and CT scan were used to determine Neer fracture classification. Immediate postoperative radiographs were assessed for quality of reduction, and compared to final follow-up radiographs to quantify loss of reduction according to the method of Gardner et al. Range of motion at final clinical follow-up was recorded, along with postoperative complications including osteonecrosis (ON). Subjective clinical outcome was assessed through the following questionnaires: Disabilities of the Arm, Shoulder and Hand (DASH); University of California, Los Angeles Shoulder Rating Scale (UCLA); and the Short-Form-36 (SF-36). The cohort was divided according to the Neer classification system and outcomes were compared between these classification groups.

**Results:** 91 proximal humerus fractures met inclusion criteria with average radiographic follow-up of 12 months. 32 fractures were classified as Neer 2-part fractures, 35 as 3-part, and 24 as 4-part. There was no difference between these groups with regard to age, gender distribution, mechanism of injury, or rate of anatomic reduction. There was no difference between 2, 3 and 4-part fractures with regard to loss of reduction, final postoperative range of motion, or the results of DASH, UCLA, and SF-36 questionnaires. ON was more frequent among 4-part fractures (16.7%, 4 of 24) compared to 2-part (3.1%, 1 of 32) or 3-part fractures (3%, 1 of 35), although this difference was not statistically significant. Among the 6 patients with ON, the average DASH, UCLA, and SF-36 mental and physical component summary scores were 31.2, 23.25, 48.9, and 61.7 and none have required a salvage operation.

**Conclusions:** The Neer classification was not predictive of clinical or radiographic outcomes among proximal humerus fractures treated with a plate and screw construct supplemented with an endosteal strut augment. The biomechanical and biologic properties of this construct may allow for more durable osteosynthesis and predictable clinical results regardless of initial fracture pattern.



### Triple and Quadruple Disruptions of the Superior Shoulder Suspensory Complex

Peter A. Cole, MD; Brett Mulawka, MS; Aaron R. Jacobson, DC;

University of Minnesota, Minneapolis, Minnesota, USA

**Background/Purpose:** Due to their association with high-energy mechanisms, scapula fractures are often characterized by complex fracture patterns of the shoulder girdle and, more specifically, the superior shoulder suspensory complex (SSSC) in approximately 30% of cases. The SSSC is made up of an osseoligamentous support that helps to suspend and orient the glenohumeral joint. Goss described the floating shoulder, in which two structures in this complex are broken or torn. Such double disruptions have been used as a criterion in establishing the need for operative stabilization. Most commonly, the two disruptions include the clavicle and scapular neck. Double lesions to the SSSC may be associated with a poorer outcome. To date, no one has described more than two lesions of the SSSC, let alone the frequency of combinations, associated demographics, associated injuries, or outcome. We identified a cohort of patients with triple or quadruple disruptions of the SSSC, and hypothesized that they would have a high rate of concomitant injury and poor outcome resulting from the force needed to produce such a lesion. The purpose of this study is to describe this unusual injury and report their combinations, associated injury rates, and functional outcomes.

**Methods:** A prospective scapula fracture database was established in 2002 with the approval of the IRB to record the operative and outcome data of patients undergoing open reduction and internal fixation. All patients met published and clearly defined operative criteria. The cohort of all patients, greater than 17 years of age, who had more than two lesions to the SSSC underwent analysis.

**Results:** 14 patients with greater than 2 disruptions (12 triple and 2 quadruple) were identified. All experienced high-energy mechanisms. The mean age is 33 years (range, 18-60) with 12 males and 2 females. A total of 44 disruptions were identified in the following locations: 13 scapula neck fractures (13 operatively treated), 7 clavicle fractures (3 operative), 6 acromioclavicular separations (5 operative), 9 coracoid (6 operative), and 9 acromion fractures (7 operative). Associated injuries outside the shoulder girdle occurred in 93% (13 of 14). Rib fractures were present in 86% (12 of 14) with a mean of 4.5 ribs fractured (range, 1-10) per patient. A fracture of the spine occurred in 57% (8 of 14) of which 1 had a complete spinal cord and 3 had complete nerve root lesions. Traumatic brain injury was documented in 70%. Additional neurologic lesions were sustained in 86% (12 of 14), with 9 of 14 patients having injury distal to the brachial plexus and the other 5 patients with nerve injury at the level of the brachial plexus. Outcomes were obtained on 13 patients (93%) with a mean follow-up of 30 months (range, 7.5-75 months). Disabilities of the Arm, Shoulder and Hand (DASH) scores averaged 14.2 (range, 0-45). Mean range of motion (ROM) when expressed as the percentage of injured ROM over contralateral ROM was 94% forward flexion, 91% abduction, and 76% external rotation. Mean strength measured by a handheld dynamometer and expressed as the percentage of injured over contralateral was 62% forward flexion, 60% abduction, and 66% external rotation.

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**Conclusion:** Patients who sustain triple and quadruple lesions to the SSSC who undergo operative stabilization of displaced fractures demonstrated satisfactory functional outcomes. Although strength was diminished, this would be expected given the high nerve injury rate. The muscular weakness did not seem to have a large effect on the patients' DASH scores or ROM given the return to near normal levels. Further studies are needed to compare to matched cohorts of patients with fewer injuries to the SSSC.

### **Socioeconomic Deprivation Predicts Outcome Following Radial Head and Neck Fractures**

*Andrew D. Duckworth, MBChB,BSc (Hons); Nicholas D. Clement, MRCSEd; Paul J. Jenkins, MRCSEd; Elizabeth M. Will, MCSP; Charles M. Court-Brown, MD; Margaret M. McQueen, MD; Edinburgh Orthopaedic Trauma Unit, Royal Infirmary of Edinburgh, Edinburgh, Scotland, United Kingdom*

**Purpose:** There is increasing evidence demonstrating an association between fracture demographics and socioeconomic status. However, the influence of socioeconomic deprivation on fracture outcome has not been documented before. The aim of this study was to determine if socioeconomic deprivation influenced the short-term outcome following a fracture of the radial head or neck.

**Methods:** We identified from a prospective database all patients who sustained a radial head or neck fracture over an 18-month period. The primary outcome measure for this study was the patient-reported Short Musculoskeletal Function Assessment (SMFA). The Index of Multiple Deprivation (IMD) was used to quantify deprivation and any correlation with functional outcome was determined. The IMD has five quintiles, one being the most deprived and five being the least deprived. Multivariate regression analysis was used to determine the influence of deprivation on outcome once other significant demographic and fracture characteristics had been accounted for.

**Results:** There were 200 patients in the study cohort, of which 107 (53.5%) were female and the mean age was 44 years (range, 16-83). At a mean follow-up of 6 months, the median SMFA score was 0.54 (range, 0-55.4). The SMFA was found to be influenced by the IMD, with increasing deprivation associated with a poorer outcome ( $P = 0.006$ ). Compared with the least deprived quintile, the SMFA was found to be increased in the most deprived (mean difference 5.60, 95% confidence interval [CI] 1.02 to 10.19) and the second most deprived quintile (mean difference 4.15, 95% CI 0.37 to 7.94). On multivariate analysis, the injury severity according to the OTA fracture classification, compensation, and increasing deprivation were the only independent predictors of outcome (all  $P < 0.05$ ).

**Conclusions:** We have shown a clear correlation between functional outcome and socioeconomic status, with the most deprived patients reporting a poorer outcome. Future work should be aimed at determining which aspects of deprivation influence patient outcome, with modifiable factors targeted in future healthcare planning.

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### Impact of Radiographic Beam Position on the Radiocapitellum Ratio (RCR) in Healthy Elbows

*Emilie Sandman, MD<sup>1,2</sup>; Fannie McCann<sup>2</sup>; Fanny Canet, MScA<sup>1</sup>; Yvan Petit, PhD<sup>1,3</sup>; George-Yves Laflamme, MD, FRCSC<sup>1</sup>; Dominique M. Rouleau<sup>1</sup>, MD, MSc, FRCSC;*

<sup>1</sup>Hôpital du Sacré-Cœur de Montréal, Montreal, Quebec, Canada;

<sup>2</sup>Université de Montréal, Montreal, Quebec, Canada;

<sup>3</sup>École de Technologie Supérieure, Montreal, Quebec, Canada,

**Background/Purpose:** The radiocapitellum ratio (RCR) is a measurement method that was defined to quantify the degree of subluxation of the radial head with the capitellum of the humerus, with a normal RCR between -5% and 13%. The RCR has good reproducibility when measured on lateral radiographs of healthy elbows with the capitellum concentric to the sulcus and the medial trochlea. However, the impact of the radiographs' quality on the RCR measurement is unknown. We hypothesized that radiographic beam position changes would objectively affect the measures of the RCR in healthy elbows, with anterior or posterior radial head dislocation.

**Methods:** Radiographs were taken and examined on six healthy cadaveric extremities. 49 different views were taken with radiographic beam angles ranging from -20° to 20° along the caudal-cranial axis and from -20° to 20° along the posterior-anterior axis. The same views were then taken on the six arms with anterior radiocapitellum dislocation followed by posterior radiocapitellum dislocation. After randomization of all the radiographs, the RCRs were measured by one observer. An analysis of variance (ANOVA) study was made to analyze the main and interactive effects on the RCR measured in each C-arm position compared to the RCR measured in the 0°-0° position (lateral radiograph).

**Results:** The mean RCR in healthy elbows was -0.5% ± 4% without subluxation, 74% ± 18% with anterior subluxation, and -71% ± 29% with posterior subluxation. The ANOVA study demonstrated a significant interactive effect between the subluxation (anterior, posterior, or no subluxation) and the position of the C-arm in caudal-cranial directions ( $P = 0.006$ ). There was no significant main effect of the anterior-posterior position on the RCR ( $P = 0.127$ ). The deviation of the RCR measured compared to the RCR on the lateral radiograph was always in the normal range when there was no subluxation. The RCR variation is especially increased with a posterior radial head subluxation, for a caudal position of the C-arm of 10° and more.

**Conclusion:** When looking at the radiograph of a reduced elbow, a lateral incidence is not crucial to confirm that the elbow is displaced or not. The caudal-cranial position of the C-arm is more important to correctly assess the value of the RCR. The RCR measurement is an interesting clinical and research tool to evaluate elbow subluxations on lateral radiographs or on radiographs with a C-arm position deviated up to 20°.

**Plain Radiographs, CT, and Three-Dimensional Reconstruction:  
A Comparative Analysis of Measured Displacement for Isolated Greater Tuberosity  
Fractures of the Proximal Humerus**

Jennifer Mutch, MD<sup>1</sup>; Dominique M. Rouleau, MD, MSc, FRCSC<sup>1</sup>;

George-Yves Laflamme, MD, FRCSC<sup>1</sup>; Nicola Hagemeister<sup>2</sup>;

<sup>1</sup>Hôpital du Sacré-Cœur de Montréal, Université de Montréal, Montreal, Quebec, Canada;

<sup>2</sup>Centre Hospitalier de l'Université de Montréal, École de Technologie Supérieure,  
Montreal, Quebec, Canada

**Background/Purpose:** Clinical outcome following isolated fractures of the greater tuberosity (GT) of the proximal humerus depends on the magnitude of displacement of the GT fragment. As little as 2 mm of displacement has been shown to have a negative impact on shoulder function. However, accurate measurement of GT displacement remains a problem and errors of up to 13 mm have been reported on plain radiography (XR) in previous studies. This study is the first to compare measured displacement of GT fractures on XR, CT, and three-dimensional CT (3DCT) in the clinical setting. A new ratio method for measuring GT fracture displacement on XR is described and validated. Fracture displacement measured using this new ratio method is correlated with displacements measured on CT and 3DCT.

**Methods:** A retrospective review of all cases of shoulder radiographs ordered by 13 orthopaedic surgeons at a single trauma center between July 2007 and December 2010 was performed. 40 cases of acute GT fractures with adequate initial XR and CT were identified and 3DCT reconstructions were performed using 3D reconstruction software. The displacement of the greater tuberosity fragment was measured in the AP and superoinferior planes on XR, CT, and 3DCT. A new ratio method for measuring GT fragment displacement on XR is described and analysis of correlation was calculated for GT displacement on XR, CT, and 3DCT using the Pearson coefficient. All data analysis was performed with SPSS v19 (IBM).

**Results:** The ratio described in this study correlates well with GT fragment displacement measured on CT for superior/inferior displacement (Pearson = 0.852,  $P < 0.01$ ). It is simple to perform and describes GT displacement with regards to a known anatomic relationship (normal GT to humeral head distance = 8 mm [SD 3.2 mm]). The 3DCT measurements taken did not correlate well with CT or XR.

**Conclusion:** The ratio technique described in this study correlates well with the gold standard for measurement of superoinferior displacement of GT fractures (CT). It involves significantly less radiation than CT and may represent a valid and attractive option for the initial evaluation and follow-up of GT fractures.

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**Dorsal Radial Blind Spot**

*Andrew K. Brown, MD; Howard Roth, MD; David A. Fuller, MD;  
Cooper University Medical Center, Camden, New Jersey, USA*

**Background/Purpose:** Management of distal radius fractures has been an ongoing evolution since before Colles first described the injury in 1814. Most recently that evolution has given rise to a trend in volar plating. The advantages afforded by this new technology (rigid stabilization, early motion, and fixation of comminuted or osteoporotic bone) are not without risk of certain novel complications. One of the most widely reported complications associated with volar plates, it seems, is extensor tendon injury. The etiology of this injury can be varied. The very nature of the fracture may itself cause injury to the extensor tendons; however, the more concerning causes of these injuries for the practicing surgeon are those that are iatrogenic. Numerous case reports and retrospective studies have shown that prominent screws extending beyond the dorsal cortex can cause acute rupture, attritional rupture, or tenosynovitis. From retrospective data it can be estimated that extensor tendon complications occur between 3% and 5% of the time. A number of anatomic factors contribute to the incidence of these complications. First, the extensor tendons sit approximately 1 mm from the dorsal cortex of the distal radius. Thus a screw with even the slightest protrusion can injure the extensors. Secondly, the dorsal cortex is exceedingly thin and is often comminuted, making accurate measurement of screw length difficult. Lastly, the geometric shape of the distal radius makes it nearly impossible to judge screw position on lateral radiographs or intraoperative fluoroscopy. While this phenomenon is not new, it has as yet to be anatomically quantified. It is with this in mind that we set about to objectively describe the anatomy of the dorsal radius with the hypothesis being that there exists a consistent extensor sulcus on the dorsal aspect of the radius, but that the sulcus depth varies on an individual basis. For purposes of this study, we refer to this sulcus as the dorsal radial blind spot given the inability to detect the sulcus on standard radiographs.

**Methods:** 61 consecutive wrist MRI studies performed for any reason were analyzed. Skeletal immaturity and fractures or bone tumors distorting the anatomy were the only exclusion criteria. Using axial views, the dorsal extensor compartment ulnar to Lister's tubercle was evaluated. Using the axial cut with the maximum sulcus depth, a line was drawn from the apex of Lister's tubercle to the dorsal ulnar corner of the radius. Measurement was then made from this line to the deepest point in the sulcus and recorded as sulcus depth.

**Results:** 61 MRI scans were evaluated (33 female, 28 male) ranging in age from 12 to 65 years. The average depth of the sulcus was 1.3 mm (range, 0.0-3.1 mm). The average sulcus depth for females was 1.34 mm and for males was 1.25 mm. The sulcus measured  $\geq 2$  mm in 13% (8 of 61) of the wrists studied.

**Conclusions:** The results of our study show that the distal radial blind spot is a consistent anatomic finding and that its depth can be up to 3 mm. These findings have led to a change of practice at our institution including revised drilling and screw length estimation techniques. Awareness of this anatomy may help reduce the incidence of devastating extensor tendon complications in patients undergoing volar plate fixation of distal radius fractures.

**Impaired Functional Outcome Associated With Perilunate Injuries of the Wrist**

*Brandon J. Yuan, MD; Sanjeev Kakar, MD; David B. Jones, MD; Peter C. Rhee, MD; Steven L. Moran, MD;*

*Department of Orthopedic Surgery, Mayo Clinic, Rochester, Minnesota, USA*

**Hypothesis:** Patients sustaining perilunate dislocations and fracture-dislocations experience impaired functional outcome with associated radiographic deterioration over time.

**Methods:** A retrospective review was conducted analyzing the outcome of all perilunate dislocations and fracture-dislocations treated within our institution from 1985 to 2009. Standardized postoperative assessments included wrist range of motion, grip strength, and Mayo Wrist Score. Preoperative and postoperative radiographs were examined to ascertain the incidence of posttraumatic arthritis. Statistical analyses used included parametric and nonparametric *t* tests.

**Results:** 94 patients were treated within our institution over the last 25 years. There were 30 perilunate dislocations and 64 fracture-dislocations (5 open and 89 closed injuries). Complete radiographic records were present in 57 patients and included 20 perilunate dislocations and 37 fracture-dislocations (4 open and 53 closed injuries). 41 patients were treated with combined volar and dorsal approaches, 11 dorsal only, and 5 volar only approaches. There were no statistically significant differences between the pure dislocation versus the fracture-dislocation groups with respect to contralateral grip strength (64% vs 68% respectively). The fracture-dislocation group tended to have improved flexion to extension arc compared to the purely ligamentous injury patients (86° vs 74°). 33% of patients underwent additional secondary procedures. The pure dislocation patients went onto a higher rate of salvage procedures compared to the fracture-dislocation patients (35% vs 5%). According to the Mayo Wrist Scores, 23% of patients had good to excellent results and at final follow up, only 59% of patients returned to work, indicating the significant morbidity associated with this injury. Normal scapholunate (SL) angles were achieved intraoperatively in 18 of 20 dislocations and 34 of 37 fracture-dislocations. At follow-up, 13 of 20 and 31 out of 37 patients within the respective groups maintained normal SL angles. The presence of a type 2 lunate did not guard against dorsal intercalated segmental instability (DISI) development. Radiographic analysis demonstrated signs of degenerative changes in both injury groups (35% dislocation only and 52% fracture-dislocation patients). This may have been attributable to difficulties in maintaining the lunate within its fossa. At latest follow-up, 16 of 20 and 31 of 37 patients within the dislocation and fracture-dislocation groups, respectively, had evidence of greater than one-third of ulnar translocation of the lunate. Compared to immediate postoperative radiographs, there was a 16% and 8% decrease in carpal height ratio at follow-up within the dislocation and fracture-dislocation patients, respectively.

**Conclusion:** Perilunate dislocations and fracture-dislocations result in significant morbidity and impaired functional outcome in patients over the long term.

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### Corrective Osteotomy for Combined Intra- and Extra-Articular Distal Radius Malunion

Geert A. Buijze, MD<sup>1</sup>; Karl-Josef Prommersberger, MD<sup>2</sup>; Juan González del Pino, MD, PhD<sup>3</sup>; Diego L. Fernandez, MD<sup>4</sup>; Jesse B. Jupiter, MD<sup>1</sup>;

<sup>1</sup>Massachusetts General Hospital, Boston, Massachusetts, USA;

<sup>2</sup>Rhön-Klinikum, Bad Neustadt an der Saale, Germany;

<sup>3</sup>Santa Cristina University Hospital, Madrid, Spain;

<sup>4</sup>Lindenhof Hospital, Bern, Switzerland

**Purpose:** This study evaluated the functional outcome of corrective osteotomy for combined intra- and extra-articular malunions of the distal radius using multiple outcome scores.

**Methods:** 18 skeletally mature patients were evaluated at an average of 78 months after corrective osteotomy for a combined intra- and extra-articular malunion of the distal part of the radius. The indication for osteotomy in all patients was the combination of an extra-articular deformity ( $\geq 15^\circ$  volar or  $\geq 10^\circ$  dorsal angulation or  $\geq 3$  mm radial shortening) and intra-articular incongruity of  $\geq 2$  mm (maximum step-off or gap) as measured on lateral and posteroanterior radiographs. The average interval from the injury to the osteotomy was 9 months. The average maximum step-off or gap of the articular surface prior to surgery was 4 mm.

**Results:** All 18 patients healed uneventfully and the final articular incongruity was reduced to 2 mm or less. Final range of motion and grip strength significantly improved ( $P < 0.05$ ), averaging 89% and 84% of the uninjured side, and 185% and 241% of the preoperative measures, respectively. The rate of excellent or good results was 72% according to the validated rating system Mayo Modified Wrist Score, and 89% according to the unvalidated system of Gartland and Werley. The mean Disabilities of the Arm, Shoulder and Hand (DASH) score was 11, which corresponds to mild perceived disability. 11 of the 18 cases normalized their upper limb function. Four patients had complications that were successfully treated. According to the rating system of Knirk and Jupiter, four had a Grade 1 and one had a Grade 2 osteoarthritis of the radiocarpal joint on radiographs. Only two of these patients reported occasional mild pain. Radiographic osteoarthritis did not correlate with strength, motion and wrist scores.

**Conclusion:** Outcomes of corrective osteotomy for combined intra- and extra-articular malunions are comparable to those of osteotomy for isolated intra- and extra-articular malunions. If carefully planned, a corrective osteotomy for the treatment of complex intra- and extra-articular distal radius malunions can improve wrist function.



**Treatment of Acute Versus Chronic Proximal Row Carpal Injuries***Eric R. Wagner, MD<sup>1</sup>; Robert R. Gray, MD<sup>2</sup>; Sanjeev Kakar, MD<sup>1</sup>;**<sup>1</sup>Mayo Clinic, Rochester, Minnesota, USA;**<sup>2</sup>University of Miami Health Systems, Miami, Florida, USA*

**Purpose:** Currently, there is limited information regarding the clinical outcomes following percutaneous pinning of proximal carpal row injuries. The purpose of this study was to compare percutaneous pinning and capsulodesis of predynamic or dynamic proximal carpal instability versus pinning alone.

**Methods:** A retrospective chart review from was conducted of all patients with carpal instability from 1998 to 2008. Patients with predynamic or dynamic scapholunate or lunotriquetral ligament injury treated with percutaneous pinning alone or in conjunction with primary repair or dorsal capsulodesis were identified. We excluded all patients who had sustained perilunate lesser arc or greater arc injuries. Pre- and postoperative radiographs were evaluated for scapholunate diastasis, radioscapoid, and scapholunate angles. Pre- and postoperative Mayo wrist scores (MWS) and visual analog scale (VAS) scores were obtained.

**Results:** 61 patients with predynamic and dynamic injuries were identified with an average follow-up of 22.3 months. Postoperative immobilization averaged 6.6 weeks. The VAS scores decreased from 5.3 ( $\pm 1.6$ ) preoperatively to 2.1 ( $\pm 2.0$ ) after surgery with a mean difference of 3.1 ( $P < 0.001$ ). The mean MWS improved from 63.2 ( $\pm 16$ ) preoperatively to 72.0 ( $\pm 16$ ) after surgery at the last follow up appointment, with an average improvement of 6.1 points ( $P < 0.01$ ). Postoperative MWS improved when the procedures with concomitant open reduction and internal fixation (ORIF) of distal radius fracture ( $P < 0.01$ ). No other variable demonstrated significant improvements in postoperative MWS. Factors associated with improved pre- to postoperative MWS include acute injuries ( $P < 0.01$ ), male gender ( $P < 0.02$ ), concomitant distal radius ORIF ( $P < 0.01$ ), no active workers' compensation claims ( $P < 0.05$ ), and no previous surgeries ( $P < 0.04$ ). Although there was a significant improvement when comparing preoperative to postoperative VAS scores among most variables, among only postoperative VAS scores, male gender ( $P < 0.05$ ) and the presence of a concomitant distal radius ORIF ( $P < 0.01$ ) led to an improved comparative postoperative pain level. No other variable had a significant effect on postoperative pain level. The average pre- and postoperative scapholunate intervals measured 1.9 mm and 2.1 mm for all patients ( $P > 0.80$ ). The average pre- and postoperative scapholunate angles were 58.6° and 62.5°, respectively ( $P > 0.80$ ).

**Conclusions:** These results suggest that percutaneous pinning of predynamic and dynamic proximal carpal row injuries does not significantly improve clinical outcomes, except in the case of concomitant distal radius fracture. Other factors that improve results include no workers' compensation claims, male gender, first-time operation, and possibly acute injuries. Open repair or capsulodesis did not seem to improve the outcomes.

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**External Fixation Versus Open Reduction With Plate Fixation for Distal Radius Fractures: A Meta-Analysis of Randomized Controlled Trials**

*Paul R.T. Kuzyk, MASC, MD, FRCS(C); John Esposito, MD; Michel Saccone, BSc;*

*Emil H. Schemitsch, MD, FRCS(C);*

*Division of Orthopaedics, Department of Surgery, University of Toronto, Toronto, Ontario, Canada*

**Purpose:** Both external fixation and open reduction with internal fixation (ORIF) using plates have been recommended for treatment of distal radius fractures. We conducted a systematic review and meta-analysis of randomized controlled trials comparing external fixation to ORIF with plate fixation.

**Methods:** MEDLINE, Embase, and Cochrane databases were searched from inception to January 2011 for all trials involving use of ORIF with plate fixation and external fixation for distal radius fractures. Eligibility criteria for inclusion in the review were use of random allocation of treatments, treatment arm receiving external fixation, and treatment arm receiving ORIF with plate fixation. Eligible studies were obtained and read in full by two coauthors who then independently applied the Checklist to Evaluate a Report of a Nonpharmacological Trial. Pooled mean differences were calculated for the following continuous outcomes: wrist range of motion; radiographic parameters; grip strength; and Disabilities of the Arm, Shoulder and Hand (DASH) score. Pooled risk ratios were calculated for rates of complications and reoperation.

**Results:** The literature search strategy identified 52 potential publications of which 9 publications (10 studies) met inclusion criteria. The pooled mean difference for DASH scores was significantly less for the ORIF with plate fixation group ( $-5.92$ , 95% confidence interval [CI]  $-9.89$  to  $-1.96$ ,  $P < 0.01$ ,  $I^2 = 39\%$ ). The pooled mean difference for ulnar variance was significantly less in the ORIF with plate fixation group ( $-0.70$ , 95% CI  $-1.20$  to  $-0.19$ ,  $P = 0.006$ ,  $I^2 = 0\%$ ), indicating better restoration of radial length for this group. The pooled risk ratio for infection was  $0.37$  (95% CI  $0.19$  to  $0.73$ ,  $P = 0.004$ ,  $I^2 = 0\%$ ), favoring ORIF with plate fixation. There were no significant differences in all other clinical outcomes. Pooled data for most outcomes were improved by including data from the four studies using volar plates exclusively.

**Conclusions:** ORIF with plate fixation provides lower DASH scores, better restoration of radial length, and reduced infection rates as compared to external fixation for treatment of distal radius fractures.

**A Biomechanical Study of Distal Volar Radius Plates for the Treatment of Distal Radius Osteotomies: Are they Able to Withstand Cyclic Physiologic Loads Thus Allowing Early Active Range of Motion?**

*Alexandra C.R. Stratton, MD; Amy Hsiao, PhD; Andrew Furey, MD;*

*Craig Stone, MD; Chris Hamilton, MD;*

*Health Sciences Center, Memorial University of Newfoundland,*

*St. Johns, Newfoundland, Canada*

**Purpose:** Multiple studies have tested distal radius plates on dorsal wedge osteotomies at physiologic load. It is not clear in the literature, however, whether volar locking plates are able to withstand active range of motion (ROM). Our study endeavored to determine whether volar distal radius locking plates used to stabilize dorsal distal radius osteotomies are able to withstand the force required for early active ROM postoperatively, thereby enabling basic activities of daily living (ADLs).

**Methods:** Dorsal wedge osteotomies were performed on 10 distal radii Sawbones with a 6-mm dorsal gap and 2-mm volar gap. Five pairs of distal radius plates were applied to fix the radii, four volar and one dorsal. Cyclic axial loading at 350 N was performed to simulate light ADLs and the constructs were cycled to failure. The load was calculated using 250 N to simulate the force of the tendons across the wrist joint plus 100 N for active wrist motion. The number of cycles leading to failure of the plates was recorded for each plate. Failure was defined as physical contact between the dorsal cortices (originally a 6-mm gap).

**Results:** The pair of dorsal plates outlasted all of the volar plates. Six of the eight volar locking plates failed within four cycles. One pair failed at 900 and 3000 cycles.

**Conclusion:** Volar locking plates to stabilize dorsal wedge osteotomies of the distal radius are not able to withstand the force required for active wrist ROM. Light ADLs are therefore not recommended following dorsal wedge osteotomy fixed with volar locking plates.

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## Does Patient Willingness to Randomize to Treatment Affect Self-Reported Satisfaction After Distal Radius Fracture?

Kenneth J. Koval, MD<sup>1</sup>; Kevin F. Spratt, PhD<sup>2</sup>;

<sup>1</sup>Orlando Regional Medical Center, Orlando, Florida, USA;

<sup>2</sup>Department of Orthopaedic Surgery, Dartmouth Medical Center, Lebanon, New Hampshire, USA

**Background/Purpose:** Most randomized trials on distal radius fractures have studied the effect of patient demographic and treatment factors on outcome. However, there is literature suggesting that the willingness of the patient to participate in a randomized controlled trial has an effect on self-reported outcomes. This study was performed to evaluate whether patient satisfaction after surgical treatment of a distal radius fracture was related to patient willingness to randomize to different methods of fixation.

**Methods:** Patients between 18 and 85 years of age who sustained an isolated distal radius fracture considered to be potentially unstable were enrolled in a multicenter prospective randomized trial of locked volar plate versus external fixation with a concurrent observational cohort for patients who wished to choose their own method of treatment. Patients were followed at 6, 13, 26, and 52-week intervals. Outcomes of interest were satisfaction with residual symptoms and overall treatment results at each of the follow-up periods. Baseline patient demographics were compared between patients who randomized to treatment versus those who preferred to choose their method of fixation.

**Results:** Between May 2005 and May 2010, 160 patients across 4 centers were enrolled into the prospective trial. For the entire cohort, 70% were women with an average age of 50.5 years (range, 19-85 years). 52% sustained an intra-articular and 48% an extra-articular fracture; 69% were treated with a locked volar plate and 31% with external fixation. 34% of patients were willing to randomize to treatment while 66% preferred to choose their method of fixation. Patient willingness to randomize to treatment was *not* significantly related to any demographic factors. However, patients who preferred to choose their method of fixation were significantly more likely to choose internal over external fixation (80% vs 20%,  $P < 0.0001$ ). Patient satisfaction with residual symptoms and overall treatment results both demonstrated significant improvement across follow-up intervals ( $P < 0.0001$ ); however, differences in satisfaction between randomized versus preference patient groups never reached statistical significance. Only at 6-month follow-up was there a trend observed with the preference group reporting higher satisfaction with their residual symptoms compared to the randomized group (3.86 vs 3.33,  $P < 0.061$ ).

**Conclusions:** Contrary to expectation, patient willingness to randomize to internal versus external fixation did not affect self-reported satisfaction after distal radius fracture. Regardless of fixation method or willingness to randomize to treatment, patient satisfaction demonstrated significant improvement over time.

**Predictors of Nonunion Following a Fracture of the Scaphoid**

*Andrew D. Duckworth, MBChB, BSc (Hons); Kate E. Bugler, MRCSEd; Nicholas D. Clement, MRCSEd; Stuart A. Aitken; Margaret M. McQueen, MD; Edinburgh Orthopaedic Trauma Unit, Royal Infirmary of Edinburgh, Edinburgh, Scotland, United Kingdom*

**Purpose:** Nonunion following a fracture of the scaphoid can be a significant cause of morbidity in a young and active population. The aim of this study was to identify risk factors for nonunion following a fracture of the scaphoid.

**Methods:** We identified from a prospective database all patients who sustained a scaphoid fracture over a 1-year period. Demographic data, time to presentation, treatment, complications, and subsequent procedures were recorded. We recorded all potential predisposing factors including chronic medical comorbidities, alcohol excess, and smoking. The main outcome measure was non-union, which was defined as absence of trabeculae crossing at the fracture site with a persistent fracture gap and tenderness at 12 to 16 weeks post injury. Statistical analysis was used to determine significant ( $P < 0.05$ ) predictors of scaphoid fracture nonunion.

**Results:** There were 151 patients who sustained a scaphoid fracture over a 1-year period with a median age of 27 years, of whom 105 (69.5%) were males and 46 (30.5%) were females. The most common fracture according to the Herbert classification was the type B2 ( $n = 59$ , 39.1%). The overall number of type A injuries was 47 (31.1%), with type B accounting for 104 (68.9%) fractures. 23 patients (15%) underwent acute primary fixation, with 8 (5.9%) managed with acute open reduction and internal fixation and 15 (11%) managed with percutaneous fixation. 15 had inadequate follow-up data, leaving a total of 136 (90%) patients for analysis. Union occurred in 123 patients (90.4%), with nonunion diagnosed in 13 patients (9.6%). The rate of nonunion was highest in the B3 (29%) and B5 (20%) fracture subtypes, which was approaching significance (0.15). The rate of nonunion in patients with a background of alcohol abuse was 24%, again approaching significance (0.08). The only significant predictor of nonunion was delayed presentation or management ( $P < 0.001$ ), with every patient managed after 4 weeks sustaining a nonunion.

**Conclusion:** A nonunion rate for scaphoid fractures of almost 10% is comparable to previously published data. This is one of the first studies to clearly document that delayed management is most predictive of scaphoid fracture nonunion, with a delay of greater than 4 weeks being critical. Further work is needed with increased numbers to determine if risk factors such as fracture classification and alcohol excess may prove to be significant.

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### **A Novel, Multiplanar and Less-Invasive Approach to Distal Radius Fracture Fixation: A Prospective Case Series**

Michael Strassmair, MD<sup>1</sup>; Daniel R. Rikli<sup>2</sup>; Jörg Schmidt, MD<sup>3</sup>; Hand-Josef Erli, MD<sup>4</sup>; Joseph Hale<sup>5</sup>; Andrew H. Schmidt, MD<sup>6</sup>; Thomas M. Walsh, MD<sup>7</sup>; Steven L. Moran<sup>8</sup>;

<sup>1</sup>Klinikum Starnberg, Starnberg Germany;

<sup>2</sup>Universitätsspital Basel, Basel, Switzerland;

<sup>3</sup>Weissenfels, Berlin, Germany;

<sup>4</sup>Vivantes Humboldt Klinikum, Berlin, Germany;

<sup>5</sup>Conventus Orthopaedics, Maple Grove, Minnesota, USA;

<sup>6</sup>Hennepin County Medical Center, Minneapolis, Minnesota, USA;

<sup>7</sup>Park Nicollet Health Services, Minneapolis, Minnesota, USA;

<sup>8</sup>Mayo Clinic, Rochester, Minnesota, USA

**Background/Purpose:** The majority of surgically managed distal radius fractures are treated using volar locking plates; however, the procedure is relatively invasive and complications are not uncommon. The need still exists for a surgical solution that minimizes trauma, avoids tendon irritation, and addresses a broad range of fracture patterns. This study assesses outcomes for patients treated using a novel, intramedullary fracture fixation system to which fragments can be reassembled and stabilized using screws placed in any plane as dictated by the fracture pattern. Axial and bending stiffness of this device has previously been shown to be comparable to that of volar locked plates.

**Methods:** A multicenter, prospective case study was performed in patients undergoing internal fixation of a distal radius fracture using an expandable, intramedullary scaffold. Study protocol was approved within the clinical investigators' respective institutions and countries. Patient outcome was assessed based on serial radiographs, adverse event reporting, and Disabilities of the Arm, Shoulder and Hand (DASH) scores, with a study end point of 12 weeks postoperatively. *Surgical Technique:* Following provisional reduction with Kirschner wires (K-wires), a small incision and 5-mm-diameter cortical hole are created on the lateral aspect of the radius, approximately 7 cm proximal to the fracture site. An expandable broach is used to prepare the metaphysis for implant insertion. A compressed nitinol scaffold is then introduced into the medullary canal and allowed to expand within the prepared metaphyseal site. Cannulated bone screws are percutaneously inserted over K-wires placed through fracture fragments and into the expanded scaffold. Screw quantity, type, and orientation can be tailored to the individual fracture pattern.

**Results:** 40 patients have undergone surgery (35 female; age range, 20-91 years), with days since implant ranging from 43 to 470. In all cases, analysis of immediate postoperative radiographs showed acceptable reduction; serial radiographs confirmed no loss of reduction at subsequent follow-up, with evidence of bony union by 12 weeks. Only two postoperative adverse events were documented—irritation of the superficial branch of the radial nerve, which spontaneously resolved by 6 weeks, and a nonspecific nerve injury with mild symptoms that continues to be followed. The mean DASH score for all subjects for whom 12-week follow-up had been completed (n = 24) was 21.7 ± 12.1, representing a mean improvement of 70.3% compared with scores at the time of screening.

See pages 97 - 144 for financial disclosure information.

**Conclusions:** Clinical experience with this new technique for intramedullary management of distal radius fractures continues to be promising. This prospectively documented series demonstrates the technique's ability to deliver stable fixation through a tissue-preserving approach and maintain reduction throughout the healing phase, with fewer complications than reported for volar locked plating.

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### **The Relationship Between Length of Stay and ASA Class in the Surgical Treatment of the Orthopaedic Trauma Patient**

Zachary Yoneda, BS; A. Alex Jahangir, MD; Jesse Ehrenfeld, MD, MPH; Mallory Powell, BA; William T. Obremsky, MD, MPH; Manish K. Sethi, MD; Vanderbilt University Medical Center, Nashville, Tennessee, USA

**Background/Purpose:** As healthcare costs continue to exponentially increase, the orthopaedic trauma surgeon will be faced with new challenges to consider cost containment. In the era of significant healthcare reform aimed at decreasing healthcare costs and transforming reimbursement models, it is critical to identify factors that impact the prognosis and costs of the surgical management of orthopaedic trauma injuries. One parameter that can potentially result in increased healthcare costs is the increased length of stay during the postoperative period following surgical management of fractures. The purpose of this study is to identify the factors that contribute to increased length of stay after surgical management of fractures, and therefore lead to increased overall costs in the treatment of the elderly hip fracture.

**Methods:** From January 2000 through December 2010, all patients who underwent operative management of a fracture were reviewed. These patients' charts were reviewed and information was gleaned including gender, length of surgery, length of operative procedure, method of fixation, American Society of Anesthesiologists (ASA) classification, and medical comorbidities. Analysis of variance (ANOVA) was conducted to determine validity of the ASA class in predicting length of stay trends.

**Results:** 10,381 patients were identified who had complete records able to be analyzed and met criteria for surgery. The ASA classification proved the strongest predictor of postoperative length of stay for all patients in the retrospective cohort, even after accounting for procedure type, age, gender, and comorbid conditions. For each ASA increase of 1, average subsequent length of hospitalization increased by 4.6 days ( $P < 0.001$ ) compared to the average for a given procedure. Utilizing the fact that the average total daily cost to the hospital for a 24-hour inpatient stay on the surgical ward was determined to be \$4530 for postsurgical patients, each point increase in ASA classification resulted in an increase of \$20,721.78 in hospital cost for each patient undergoing an average orthopaedic procedure. Thus a patient who is an ASA of 5 will incur on average \$82,887.12 more expense to the hospital than a patient with an ASA of 1 for a given orthopaedic procedure.

**Conclusion:** This study reinforces the usefulness of the ASA classification in estimating the length of stay for patients undergoing surgical management of orthopaedic trauma injuries. Furthermore, this study demonstrates the powerful nature of the ASA classification, when coupled with the procedure in question, for explanation of variance of length of stay for hospitalized patients. Given that ASA classification and daily cost are universally collected data, this method can easily be employed in almost any hospital system and for any operative service. With refinement, this model may be used to predict more accurately than before a patient's postoperative course and thus the expected cost to the healthcare system of a given procedure.



**Implementation of Usage Guidelines for Bone Graft Products Reduces Costs***Megan A. Brady, MD; Heather A. Vallier, MD; John H. Wilber, MD;**MetroHealth Medical Center, Cleveland, Ohio, USA*

**Background/Purpose:** Bone graft products, such as allograft bone, demineralized bone matrix, ceramics, and growth factors (bone morphogenetic proteins [BMPs]), are useful adjuncts to acute fracture care and musculoskeletal reconstruction, and as alternatives to autogenous bone grafting. However, they are also often associated with high costs. A multidisciplinary team of surgeons and operating room administrators established practice guidelines for structural and nonstructural bone graft products and growth factors. An inventory of these products and permitted bone graft substitutes was developed to minimize the number of available products and vendors and to contain costs, while not affecting quality of patient outcome. Non-FDA (US Food and Drug Administration)-approved usage of BMP-2 or osteogenic protein (OP)-1 (BMP-7) was allowed through patient prepayment only. FDA-approved usage was permitted and preauthorization and payment by insurance carriers was obtained. The purpose of the project was to characterize the experience of this trauma center for the 3 years following implementation of these recommendations.

**Methods:** Recommendations were implemented in July of 2008. The type and amount of bone graft products, including allograft bone, bone graft substitutes, and growth factors were determined for each of the following years: 2007 (preimplementation), 2009, 2010, and 2011. 2008 was excluded, to allow 6 months for transition to the new inventory and recommendations. Hospital costs for purchasing and carrying the bone graft products were determined.

**Results:** The total cost of bone graft products decreased from \$470,013 to \$78,042 (83%) by 2011. The majority of savings resulted from eliminated demineralized bone matrix products and ceramics, with increased usage of less expensive allograft chips. Chip usage increased from 74 vials in 2007 to 136 vials by 2011. Despite the larger number, the total cost decreased by \$3100 by having both 15-cm<sup>3</sup> (\$269 each) and 30-cm<sup>3</sup> (\$339 each) sizes available, versus only the larger size in 2007, which was often partially wasted. Structural allografts from a single vendor with the lowest price were also used, resulting in 91% reduction in costs by 2011. Loss due to expired inventory did not occur after 2008, and growth factor costs had declined by 84% in 2011. Additionally, in most cases improved revenue was seen by the hospital when using growth factors and arranging preauthorization. The volume of acute fracture, nonunion, and arthrodesis cases did not vary significantly between 2007 and 2011, nor did the frequency of new nonunions increase. Despite stable surgical case load, the bone graft initiative resulted in over \$350,000 saved each year—over \$1.1 million during 3 years.

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	2007	2009	2010	2011
Allograft croutons	\$25,086	\$42,741	\$36,097	\$39,308
Structural allograft	\$106,666	\$21,413	\$12,147	\$9,376
Bone graft substitutes	\$118,481	\$17,807	0	0
Growth factors	\$185,780	\$33,697	\$57,789	\$29,358
Expired inventory (waste)	\$34,000	0	0	0
Total	\$470,013	\$115,658	\$106,033	\$78,042

**Discussion/Conclusions:** Implementation of guidelines for bone graft product usage and simplification of inventory led to a substantial cost savings and decreased material waste. Additionally, the hospital experienced better charge capture by obtaining preauthorization for BMP. These basic interventions resulted in annual savings of \$392,000 (83% decrease) by 2011, accounting for 3.27% reduction from a total annual operating room materials expense of \$12 million. These minor changes continued to allow surgeons to provide excellent care, with minimal inconvenience and no measurable adverse effects on union rates.

**Massachusetts Health Care Reform:  
Its Effect on the Percentage of Uninsured Patients and the Reimbursement  
for Provider Services at Academic Urban Level I Trauma Centers**

*R. James Toussaint, MD<sup>1</sup>; Michael J. Weaver, MD<sup>1</sup>; Paul Tornetta, III, MD<sup>2</sup>;  
Mark S. Vrahas, MD<sup>1</sup>; Mitchel B. Harris, MD<sup>1</sup>;*

*<sup>1</sup>Brigham and Women's Hospital, Boston, Massachusetts, USA;*

*<sup>2</sup>Boston Medical Center, Boston, Massachusetts, USA*

**Background/Purpose:** On April 12, 2006, the Massachusetts legislature approved its landmark health care reform law (also known as Chapter 58 of the Acts of 2006 or "Mass Health Reform" [MHR]) to provide health insurance coverage for all of its residents. MHR sought not only to provide uninsured residents with insurance coverage, but also to appropriately compensate hospitals and providers for their services. The purpose of this study is to evaluate the demographic and economic effects of Chapter 58 on the orthopaedic trauma population of three metropolitan Level I trauma centers.

**Methods:** We performed an IRB-approved retrospective review of all non-spine fracture and dislocation cases for patients less than 65 years old treated by the orthopaedic trauma services of three of the four Level I trauma centers in a major metropolitan area from 2003 to 2010. All out-of-state patients were excluded since they are not under the jurisdiction of MHR. The years 2006 and 2007 were excluded in order to remove the effects of volatility in the insurance market during the enrollment period. The population was divided into two groups: Group 1 included cases from January 2003 to December 2005 and consisted of patients treated for fractures and dislocations prior to the enactment of MHR; Group 2 consisted of patients from January 2008 to December 2010 who were treated subsequent to MHR. Relative Value Unit (RVU) data, CPT codes, financial data, and patient insurance classification were compared between the two groups.

**Results:** The final study cohort included 12,955 patients (5318 in Group 1 and 7637 in Group 2, a 43.6% increase). There were 18,210 procedures (462 in Group 1 and 10,748 in Group 2, a 44.0% increase). The percentage of patients who were uninsured in Group 1 was 27.4%; the percentage of uninsured patients in Group 2 decreased to 17.3%. There was a 44.0% increase in RVUs from Group 1 to Group 2. After analyzing two-thirds of the available data, the annual growth rate in revenue collections per RVU was 1.0% from Group 1 to Group 2 compared to 2.2% for the Medicare Economic Index during the same period.

**Conclusion:** Massachusetts health care reform has resulted in a 36.8% decrease in the percentage of uninsured patients treated for fractures and dislocations at three of four Level I trauma centers in a major metropolitan area. Despite this improvement, nearly one out of five trauma patients at the urban trauma centers did not have health insurance. During this same time period, the Medicare Economic Index grew at a pace over twice that of the centers' collections per RVU.

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**What Macroeconomic Factors Affect Orthopaedic Trauma Volume?**

*David A. Hamilton, MD, MBA; Daniel L. Davenport, PhD, MBA; Jeffrey B. Selby, MD; Eric S. Moghadamian, MD; Brandon T. Bruce, MD; Raymond D. Wright, MD; University of Kentucky Department of Orthopaedic Surgery, Lexington, Kentucky, USA*

**Purpose:** An understanding of macroeconomic factors that affect the demand for orthopaedic care allows for higher quality of care through better planning and resource allocation. Orthopaedic trauma volume is thought to be inversely correlated with the unemployment rate. Proposed reasons for this correlation are numerous. The purpose of this study is to determine what factors affect trauma volume at our Level I trauma institution.

**Methods:** A retrospective analysis of the trauma registry at our institution was conducted to determine monthly trauma admission volume from January 1, 1995 to December 31, 2010. Admissions were sorted by cause code including motor vehicle crash (MVC), motorcycle crash (MCC), all-terrain vehicle accident (ATV), assaults, gunshot wounds (GSW), and stabblings. Monthly data from the trauma registry were compared to state population, crime, and unemployment data as well as national macroeconomic indicators such as the Dow Jones Industrial Average (DJIA), vehicle miles driven, consumer confidence index (CCI), and quarterly gross domestic product (GDP). Month-to-month changes in all variables were analyzed in an attempt to control for the background population increase over the 16-year time period. Pearson correlation (PC) tests were performed to determine which factors correlated with trauma admission volume. Variables with statistically significant correlation were further examined using a multivariable linear regression model to determine their independent contribution to trauma volume. The multivariable regression also included calendar quarter as a seasonal adjustment.

**Results:** Overall, MVC accounted for 40.3% of trauma admissions at our institution during this time period. There was no significant correlation demonstrated between trauma admission volume and national economic indicators such as the DJIA ( $P = 0.796$ ), CCI ( $P = 0.220$ ), and quarterly GDP ( $P = 0.105$ ). However, there was a significant correlation between changes in trauma admission volume and national per capita vehicle miles driven ( $PC = 0.568$ ;  $P < 0.001$ ), state level monthly unemployment rate ( $PC = -0.389$ ;  $P < 0.001$ ), and monthly crime volume ( $PC = 0.430$ ;  $P < 0.001$ ) changes. The multivariable regression model with seasonal adjustment confirmed independent prediction of trauma volume by vehicle miles driven (significance  $< 0.001$ ) and state unemployment rate ( $P = 0.010$ ). State crime volume was not an independent predictor of trauma volume ( $P = 0.814$ ) in the multivariable regression model.

**Conclusion:** There appears to be no correlation between trauma volume and national level economic indicators such as the DJIA, CCI, and GDP. We confirmed an inverse correlation between trauma admission volume and the state unemployment rate at our institution. The positive correlation between national vehicle miles driven and trauma volume is not surprising since MVC is the most common injury etiology for hospitalized trauma patients at our Level I trauma center. It is unclear what role the crime rate plays in trauma admission volume. It appears the unemployment rate and vehicle miles driven are more strongly correlated with trauma volume than the crime rate.

See pages 97 - 144 for financial disclosure information.

### Are Orthopaedic Trauma Jobs Scarce?

William T. Obrebsky, MD, MPH<sup>1</sup>; Kyle Judd, MD<sup>1</sup>; Lisa K. Cannada, MD<sup>2</sup>;

<sup>1</sup>Vanderbilt University Medical Center, Nashville, Tennessee, USA

<sup>2</sup>Saint Louis University, Saint Louis, Missouri, USA

**Purpose:** Recent trauma fellows are concerned that they will have difficulty finding a job. Our hypothesis is the increased number of trauma fellows has led to a decrease in advertised trauma positions.

**Methods:** The number of applicants for trauma fellowships was obtained and the survey results indicating job position. To determine the number of advertised positions, a review and tabulation of the advertised orthopaedic trauma jobs and job type for the past 5 years (2006-2011) was completed. The following journals were used to review the number of advertised jobs: *The Journal of Bone and Joint Surgery–American Volume* (JBJS) and the *Journal of Orthopaedic Trauma* (JOT). In addition, we also tallied the number of advertised trauma positions on the American Academy of Orthopaedic Surgeons (AAOS) and the OTA websites.

#### Results:

	2011	2010	2009	2008	2007	2005	2004	2003
# Positions filled	64	74	69	75	76	57	35	19
# Positions	81	82	81	79	84	69	63	58
# Programs	52	48	48	45	49	39	34	34
# Total ads	16		26		42	60		74
# Academic ads	8		14		17	29		37
# Ortho group jobs	6		7		21	23		25
# Multispecialty ads	2		5		3	7		8
# Hospital-based jobs	2		0		1	1		4
2006: No formal match								

**Conclusions:** The number of trauma fellows has increased significantly in the last decade from 19 to 64. The number of trauma fellowship positions available has increased slightly from 58 to 81. We found that from 2003 to 2011, fewer advertisements were seen for total number of positions (down from 74 to 16). This is true for academic (37 to 8) and ortho group practices (25 to 6). We found a decrease in hospital-based and multispecialty group advertisements as well. The increase in number of orthopaedic trauma fellows correlates closely with a decrease in advertisements for orthopaedic trauma jobs.

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### Orthopaedic Trauma Surgeons' Compliance with OTA Meeting Poster Guidelines

*Meir Marmor, MD; Amir M. Matityahu, MD;*

*Orthopaedic Trauma Institute, San Francisco General Hospital,*

*University of California San Francisco, San Francisco, California, USA*

**Purpose:** The OTA meeting has very specific guidelines for poster preparation. Specifically, it is stated that posters should be made the size of 48 inches horizontal by 48 inches vertical and that they must include a US Food and Drug Administration (FDA) approval notice as well as financial support disclosure. Both these guidelines are stated or referred to in bold typing with increased font size. The aim of this study was to evaluate compliance with the OTA poster presenter guidelines.

**Methods:** The posters presented in the OTA 27th annual meeting (October 12-15, 2011, San Antonio, Texas) were photographed, measured and analyzed using image analysis software (ImageJ). The measurements were compared to the published guidelines. Geographic origins of the authors were noted.

**Results:** 107 posters were accepted to the meeting, of which 106 were presented. Overall, compliance with sizing and disclosure guidelines was 41.51% and 54.72% respectively. Authors from the US were more compliant with the sizing guideline and less compliant with the disclosure guideline (table).

**Conclusions:** Orthopaedic trauma surgeons demonstrated poor compliance with OTA meeting poster guidelines. We hope that this is not an indication of our ability to follow other sets of guidelines.

Authors origin	Size Compliance				Disclosure Compliance			
	No.	Non-compliant	Compliant	Almost	No.	Non-compliant	Compliant	Almost
Overall	106	45.28%	41.51%	13.21%	106	54.72%	26.42%	18.87%
US	82	43.90%	45.12%	10.98%	82	54.88%	24.39%	20.73%
Non-US	24	50.00%	29.17%	20.83%	24	54.17%	33.33%	12.50%
N. America	92	41.30%	46.74%	11.96%	92	55.43%	26.09%	18.48%
Non-N. America	14	71.43%	7.14%	21.43%	14	50.00%	28.57%	21.43%



See pages 97 - 144 for financial disclosure information.

## Does a Dedicated Geriatrics Service Improve Outcomes and Decrease Length of Stay for Nonagenarians With Operatively Treated Hip Fractures?

Abbey Gore, MD; James N. DeBritz, MD; Robert D. Golden, MD;

MedStar Washington Hospital Center, Washington, District of Columbia, USA

**Purpose:** Previous hip fracture studies have shown that operatively treated patients over 90 years of age have low perioperative morbidity and mortality. To date, there have been no reports on admitting service for nonagenarians with hip fractures with respect to postsurgical outcomes and length of stay (LOS). The purpose of this study was to evaluate outcomes for nonagenarians treated for hip fractures, with a hypothesis that admission to a designated geriatrics service would decrease length of stay and improve patient outcomes.

**Methods:** A retrospective review of a prospectively collected database was conducted for a consecutive series of hip fractures in nonagenarians at a Level I trauma center from October 2007 to May 2011. 74 fractures in 70 patients were identified. Data were collected on total LOS, time to operating room, medical comorbidities, preoperative medical events, postoperative medical complications, and mortality. Data were then stratified for comparison by admitting service. Comparison was also made to a control group of all elderly patients with hip fractures treated at the same hospital during the same treatment period.

**Results:** The average age of patients was 93.4 years old (range, 90-103; standard deviation [SD] 3.19). The overall mean LOS was 7.28 days (range, 0-21; SD 3.48) with an average time to surgery of 1.68 days (range, 0-9; SD 1.47). In the overall population, 10.8% of patients had preoperative medical events whereas 16.2% had postoperative medical complications. In-hospital mortality was 1.33%. There was no significant difference in LOS for nonagenarians as compared to the control group ( $P = 0.28$ , confidence interval [CI]  $-1.07$  to  $3.61$ ). When stratified by admitting service, LOS was significantly shorter on the geriatrics service (mean 6.49 days; range, 0-15; SD 2.96) than for patients admitted to the medicine service (mean 8.61 days; range, 4-21; SD 3.97) ( $P = 0.01$ , CI  $-3.76$  to  $-0.47$ ). Time to surgery did not vary significantly between geriatrics (G) and medicine (M) ( $P = 0.42$ , CI  $-0.43$  to  $1.02$ ). There was no difference in the number of medical comorbidities for patients in either group ( $P = 0.42$ ). Patients had a similar number of preoperative medical events (11.6% [G] vs 10.7% [M],  $P = 1.0$ ) and a statistically insignificant difference in the number of postoperative complications (9.3% [G] vs 25.0% [M],  $P = 0.09$ ) regardless of admitting service, although there appeared to be a trend toward improved outcomes in the geriatrics service patients.

**Conclusion:** Nonagenarians are becoming an increasingly larger percentage of the population and will be encountered more frequently by any orthopaedist that treats hip fractures. This study demonstrates that a team-oriented approach including a dedicated geriatrics service can result in decreased LOS for nonagenarians treated for hip fractures with a trend toward decreased postoperative complications. This may represent a significant area of cost savings for hospitals in an era of medical cost containment.

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### Health Literacy in an Orthopaedic Trauma Patient Population: Improving Patient Comprehension With Informational Intervention

James M. Tsahakis, BA; Neil M. Issar, BSc; Rishin J. Kadakia, BSc; Kristin R. Archer, PhD, DPT; Tisha Barzyk, MSN, RN, ACNP-BD; **Hassan R. Mir, MD**;  
Vanderbilt University Medical Center, Nashville, Tennessee, USA

**Background/Purpose:** Many patients have difficulty comprehending their diagnoses, treatment plans, and discharge instructions. Various interventions have been examined to improve patient comprehension, and the addition of pictorial representations to text-based information has had variable success. This study aims to evaluate the change in comprehension after orthopaedic trauma patients are given a printed informational document that includes pictorial representations.

**Methods:** Over an 8-month period, orthopaedic trauma patients at a Level I trauma center were administered a questionnaire during their first postoperative clinic visit prior to being seen by a physician. The questionnaire included questions regarding (1) which bone was fractured, (2) the type of implanted fixation, (3) weight-bearing status, (4) expected recovery time, and (5) need for deep vein thrombosis (DVT) prophylaxis. All patients received verbal instructions outlining this information at hospital discharge. During the second half of the study, patients were given an additional informational sheet with both text and pictorial representations at discharge that reinforced the material tested on the questionnaire. Multivariable logistic regression analyses were used to examine the impact of this interventional tool and performance on questions regarding surgical procedure and discharge instructions.

**Results:** 299 eligible questionnaires were collected. 146 patients were given the standard discharge instructions, while 153 patients were also administered the additional information sheet. The overall mean score on the comprehension questionnaire was 2.72 out of 5. The correct response rates were: Q1, 57.2%; Q2, 69.2%; Q3, 48.5%; Q4, 17.4%; and Q5, 79.6%. The mean score on the comprehension portion for patients who received the intervention was 2.90 compared to the mean score of 2.54 for patients who did not receive the intervention ( $P = 0.009$ ). Patients who received the intervention were 2.2 times more likely to know which bone was fractured ( $P = 0.01$ ) and 3.2 times more likely to be able to correctly name the medication(s) they were prescribed for DVT prophylaxis ( $P = 0.004$ ).

**Conclusion:** Patient comprehension of postoperative discharge instructions in an orthopaedic trauma population was significantly improved via specific text and pictorial intervention. However, the overall level of comprehension in this patient population is concerning. Future studies should determine if patient comprehension has an effect on surgical outcomes and/or patient satisfaction.



### Can It Wait Until Morning?

#### A Meta-Analysis of the Six-Hour Rule of Open Fracture Management

*Mara L. Schenker, MD; Sarah Yannascoli, MD; Keith Baldwin, MD;*

*Jaimo Ahn; Samir Mehta, MD;*

*Department of Orthopaedic Surgery, University of Pennsylvania,  
Philadelphia, Pennsylvania, USA*

**Purpose:** Existing guidelines recommend emergent surgical débridement of open fractures within 6 hours of injury. However, there is limited evidence to support the “six-hour rule.” The aim of this study was to systematically review the association between time to operative débridement of open fractures and infections.

**Methods:** A systematic computerized search of Medline, EMBASE, and Cochrane databases supplemented with a manual search of bibliographies was performed. Randomized controlled trials, and cohort studies (retrospective and prospective) evaluating the association between time to operative débridement and infections after open fractures were included after examination of abstracts and, when appropriate, full text manuscripts. Descriptive and quantitative data were extracted. A primary analysis was performed using a random effects model for cohorts who experienced early or delayed débridement. Sensitivity analyses were performed to evaluate the injury severity, depth of infection, level of evidence, and anatomic location. Study heterogeneity, criteria of methodological quality, and publication bias were also evaluated.

**Results:** Initial search identified 885 references. Of the 712 articles further inspected, 16 were included (6 prospective, and 10 retrospective cohort studies, totaling 3906 open fractures). No statistically significant difference in infection rates after open fractures was detected in these studies between those débrided early or late, according to all study time delineations. The adjusted cumulative odds ratio (OR) was 0.93 (95% confidence interval [CI]: 0.72-1.21). Sensitivity analyses demonstrated no difference in infection rates between early and late débridement according to Gustilo-Anderson classification (Type I/II OR: 0.58 [95% CI: 0.25-1.33], Type III OR: 0.84 [95% CI: 0.31-2.31]), level of evidence stratification (level II OR: 1.13 [95% CI: 0.63-2.03], level III OR: 1.04 [95% CI: 0.65-1.65]), depth of infection (deep infections OR: 1.07 [95% CI: 0.74-1.54]), or anatomic location (lower extremity only OR: 0.88 [95% CI: 0.62-1.26], tibia only OR: 0.89 [95% CI: 0.5-1.57]).

**Conclusions:** The data did not show an association between débridement time and higher overall or deep infection rates, or higher infection rates in more severe open fractures. Given the available data, it is difficult to determine the optimal time between injury, administration of antibiotics, and operative débridement that provides the best outcome after an open fracture. Ideally, any delay would be minimized without overutilization of resources. Based on our analysis, adhering to an arbitrary time window (for example, the historical “six-hour rule”) has little support in the available literature.

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### Profile of Litigation for Trauma-Related Cases Within the National Health System in the United Kingdom

Stelios Theocharakis<sup>1</sup>; A. B. McWilliams<sup>2</sup>; Kostas Makridis<sup>1</sup>; Martin H. Stone<sup>2</sup>; Nikolaos K. Kanakaris, MD<sup>1</sup>; Peter V. Giannoudis, MD<sup>1</sup>;

<sup>1</sup>Academic Department of Trauma and Orthopaedics, Leeds Teaching Hospitals, Leeds, United Kingdom;

<sup>2</sup>Leeds Musculoskeletal Biomedical Research Unit, Chapel Allerton Hospital, Leeds, United Kingdom

**Purpose:** The purpose of this study is to explore the patterns of trauma-related medical negligence claims received by the National Health Service Litigation Authority (NHSLA) from 1995 to 2010.

**Methods:** We conducted a retrospective review of all orthopaedic trauma-related claims. Cases with unclear incident details were excluded from the cohort. Trauma-related cases were identified and further analyzed in terms of: status of litigation (closed or open), etiology, time interval between incidence and complaint, amount of compensation, and cost of claims.

**Results:** Out of 8950 claims for general orthopaedic cases, 3495 (39%) were related to orthopaedic trauma incidents. The ratio of cases characterized as closed in terms of definite judgment was 87%. The period from trauma incidence to litigation ranged from 0 to 14 years (average 2.5 years). **The most common causes for litigation in order of highest rank were failure to diagnose/delay (fracture-dislocation-rupture), mistreatment, poor surgery, iatrogenic nerve/vascular damage, deformity/malunion, compartment syndrome, infection leading to amputation, pulmonary embolism, and inappropriate metal work placement.** Overall, the cost of trauma-related orthopaedic claims totaled £144.4 million. **The paid damages, which were the amount of money the patient actually received and depended on the severity of the claim, ranged from £1000 to £1.9 million (mean £18,265). Total claimants cost (patients' payments for a lawyer to pursue the case) reached £37 million.**

**Conclusion:** A large proportion of orthopaedic litigation is related to trauma cases, involving misdiagnosis or mistreatment of commonly occurring injuries. Efforts should be carried out in order to reduce the incidence of misfortunes and to protect patients from the above unexpected events.

### “Apples to Apples”: Moving to the New OTA Fracture Severity Classification in Extremity Trauma Research

Major Extremity Trauma Research Consortium (METRC);

Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA

**Background/Purpose:** The evaluation of treatment effect, limb survival, functional outcomes, performance outcomes, and resource utilization in patients with severe extremity trauma requires that injury characteristics among individuals are comparable. At present, the Gustilo-Anderson classification is the most commonly employed fracture grading system. All surgeons, however, recognize that a Type IIIB tibial fracture with no bone loss and only a 2 × 2-cm pretibial skin defect that is covered with a rotational flap is different from a Type IIIB fracture with severe contamination, a 5-cm bone defect, and loss of the anterior compartment requiring a free tissue transfer and bone defect reconstruction. Recognizing the bias the Gustilo fracture grading system introduced into extremity trauma research, the OTA developed a new Open Fracture Classification (OFC). The OTA-OFC assigns the fracture an injury severity grade in 5 domains: bone loss, muscle injury, skin injury, arterial injury, and contamination. The purpose of this study is to delineate the various component injuries in open fractures being classified as Gustilo Type IIIB by using the new OTA-OFC.

**Methods:** The Major Extremity Trauma Research Consortium (METRC) established a prospective extremity trauma registry of major operative fracture characteristics that included the OTA fracture classification and the OTA and Gustilo open fracture type. The 20 Level I trauma centers contributing to the registry averaged 36.4 “registry” cases a month for a total of 10,231 fractures in 8223 patients. 8090 fractures (79%) were in the lower extremity and 2141 fractures were in the upper extremity. 22% of the lower extremity fractures and 26% of the upper extremities were open. There were 201 Type IIIB fractures. We documented the 5 parameters of the new OTA-OFC to determine the discreet distribution of injury captured in what is currently being classified as a “Type IIIB” open fracture.

**Results:** The Type IIIB injury distributions for muscle injury and bone loss of the OTA-OFC are in the table. Although all fractures were classified as Type IIIB injuries, 9 patients had no bone loss or muscle injury (Cat 0) while 33 patients had severe bone and muscle loss. 32 patients had minimal muscle injury while 88 had the severest category.

OTA Open Fractures Classification			
	Muscle Injury		
Bone Loss	Cat 0	Cat 1	Cat 2
Cat 0	9	10	10
Cat 1	17	35	31
Cat 2	4	20	14
Cat 3	2	16	33

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**Conclusions:** As currently used, the Gustilo Type IIIB classification includes a wide variation in high-energy trauma. The spectrum of injury it represents is not amenable to appropriate comparisons for research purposes. Extremity trauma research should adopt the OTA-OFC in order to better stratify patients' injuries to enable comparison of treatments, outcomes, and resource consumption.

**The Musculoskeletal Function Assessment: Establishing Normative Data**

*Jessica C. McMichael, MD; Berton R. Moed, MD; Heidi Israel, PhD;  
Saint Louis University, Saint Louis, Missouri, USA*

**Background/Purpose:** Historically, outcomes in orthopaedic surgery had been assessed using clinical scores. Currently, functional outcome has become the important measure. The Musculoskeletal Function Assessment is a valid and reliable, patient-assessed health status questionnaire used by physicians to determine outcomes in patients with musculoskeletal disorders. Reference values for outcomes instruments establish a baseline for evaluating patient function. What have come to be accepted as reference values for the Musculoskeletal Function Assessment were published in 1999 from a small and potentially skewed sample. The purpose of this prospective study was to establish normal reference values for the Musculoskeletal Function Assessment for healthy adults.

**Methods:** A prospective, observational study was conducted to collect Musculoskeletal Function Assessment data for subjects within a 100-mile radius of our Midwestern city. Using an independent marketing firm, the Musculoskeletal Function Assessment questionnaire was administered to 452 participants randomly selected from public and proprietary data. Data was collected over a 2-year period. There were 235 male and 217 female responders. Stratification criteria included: gender, age (18-35, 36-55, 56-89), and body mass index. There were 60 in age group 18-35, 121 in age group 36-55, and 271 in age group 56-89. Z-scores were then calculated to compare differences in our sample and the data originally published in 1999. Musculoskeletal Function Assessment raw and standardized scores were calculated according to the instrument's instructions.

**Results:** Nonpatient Musculoskeletal Function Assessment values were significantly higher, indicating poorer function, in all categories and demographics when compared with the previously reported data.

**Conclusions:** This prospective study shows that, using current Musculoskeletal Function Assessment values for a nonpatient sample in and around this Midwestern city, our population's baseline function is significantly poorer than previously reported. Rather than necessarily indicating that the previously reported information was incorrect, our findings suggest that temporal and/or geographic conditions may influence Musculoskeletal Function Assessment normative data. Therefore, assessing functional outcome may be a dynamic rather than a static process, requiring periodic updating to re-establish normative data.

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## Identifying Enrollment Challenges and Discovering Research Opportunities in an Orthopaedic Trauma Consortium: The Value of a “Start-up” Registry

*Major Extremity Trauma Research Consortium (METRC);*

*Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA*

**Purpose:** The Major Extremity Trauma Research Consortium (METRC) was funded to research major challenges to the successful care of and recovery from severe extremity trauma. To assist in the design of studies that are feasible and adequately powered, a registry was established. At the present time, not all clinical centers have a registry, and those that do are not collecting data under a uniform protocol. We hypothesized that this registry would provide a good snapshot of the injuries treated by Consortium centers and would: (1) assist in making decisions regarding expansion of the Consortium to more centers, (2) identify recruitment challenges in competing projects, and (3) identify opportunities for additional studies based on the identification of high-incident injuries that were not being researched by the Consortium.

**Methods:** METRC established an IRB-approved extremity trauma registry in 20 Level I trauma centers. Patients between the ages of 18 and 84 years with operative fractures of the upper or lower extremity, pelvis, and acetabulum injuries were included. Injuries excluded were hip fractures if >60 years and wrist, hand, clavicle, ankle, and minor foot fractures. Centers entered data into the registry via the REDCap distributed data system for 365 consecutive days. Registry data included patient age, gender, disposition, OTA fracture classification, and the OTA and Gustilo open fracture type. The registry also recorded limb amputations, major nerve abnormalities, the final fixation method, and the wound closure method.

**Results:** Sites averaged 36.4 “registry” cases a month (range, 14.3-61.2), entering 10,231 fractures in 8223 patients. 8090 fractures (79%) were in the lower extremity and 2141 were in the upper extremity. 22% of the lower and 26% of the upper extremity fractures were open. Of the 2356 open fractures, 1300 (55%) were type I/II injuries, 780 (33%) were type IIIA, 203 (9%) were IIIB, and 73 (3%) were IIIC. Data on 203 surgical and traumatic amputations were captured, with 180 in the lower extremity. The table provides the annual operative case volume, by type, entered into the registry.

Fracture	OTA Code	Number	Open
Proximal humerus	11 A,B,C	415	36 (9%)
Distal humerus	13 A,B,C	300	111 (37%)
Femoral shaft	32 A,B,C	1303	257 (20%)
Distal femur	33 A,B,C	546	157 (29%)
Tibial plateau	41 A,B,C	1079	131 (12%)
Tibial shaft	42 A,B,C	1355	668 (49%)
Pilon	43 A,B,C	924	310 (34%)
Pelvis/acetabular	61/62 A,B,C	1347	57 (4%)

See pages 97 - 144 for financial disclosure information.

**Conclusions:** The registry data add significant value and insight related to the Consortium's strategic planning. Patients with type III tibia fractures are overselected for current projects, driving the need for the addition of new centers. Despite a high number of upper extremity, pelvic, hip, and femur fracture patients, these injuries are currently not being investigated by the Consortium. This information can be used to design future research.

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### **Δ Development of a Multidimensional Postoperative Pain Tool for Orthopaedic Trauma Surgery**

**Kristin R. Archer, PhD<sup>1</sup>**; Renan C. Castillo, PhD<sup>2</sup>; Christine M. Abraham, MA<sup>1</sup> Sara E. Heins<sup>2</sup>; Yanna Song, MS<sup>1</sup>; Stephen T. Wegener, PhD<sup>3</sup>; William T. Obremsky, MD, MPH<sup>1</sup>;

<sup>1</sup>Vanderbilt University Medical Center, Nashville, Tennessee, USA;

<sup>2</sup>Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA;

<sup>3</sup>Johns Hopkins Medicine, Baltimore, Maryland, USA

**Purpose:** The literature suggests there is a poor correlation between healthcare providers' and patients' pain ratings. Multidimensional questionnaires offer the greatest insight into the patient's pain experience. However, standard of practice in the hospital is to measure only pain intensity, which may be insufficient to identify trauma patients in need of more aggressive pain management. The primary objective of this study was to develop a multidimensional instrument to measure acute postoperative pain in patients with orthopaedic trauma.

**Methods:** A literature review generated items that addressed four dimensions of pain. Items were refined through 25 interviews with orthopaedic trauma clinicians and 4 focus groups with patients. 44 items were identified and reviewed by an expert panel of clinicians and researchers. The panel selected 33 items to be pretested. 50 participants were enrolled post-operatively on the orthopaedic unit of a Level I trauma center. Pain items were completed following consent and then 2x/day until hospital discharge. Visual analog scales (VAS) on pain at rest and with movement were also collected 2x/day, along with physiologic measures. Postoperative opioid analgesics (converted to oral morphine equivalents), length of stay (LOS), and demographic and injury characteristics were abstracted from the medical record. Items were eliminated based on poor distribution, low variance, and nonsignificant associations with VAS and physiologic measures, opioid consumption, or LOS. 24 items were retained and pilot tested on 203 patients admitted for lower extremity (80%), upper extremity (12%), and pelvis/acetabular (8%) injuries. An assessment at hospital discharge measured pain, self-efficacy, and psychological distress. Items were assessed using descriptive statistics, mixed effect models to examine associations with VAS and physiologic measures, and hierarchical multivariable regression analyses to examine predictive validity with pain, self-efficacy, psychological distress, opioid consumption, and LOS. Spearman coefficients examined correlations between items. Final items were evaluated using principal components and exploratory factor analysis and Cronbach's alpha.

**Results:** Based on the pilot test, items were removed due to poor distribution and missing data (n = 2), nonsignificant associations with VAS (n = 2) and physiologic measures (n = 3), and inability to predict discharge outcomes (n = 7) ( $P > 0.05$ ). Two items were also removed that were highly correlated with other items ( $r > 0.50$ ) and were less predictive of outcomes. The final instrument consisted of eight items. Two factors were identified that accounted for 56% of the variance in the items. Factor 1 included items on pain right now, unbearable pain, and the ability to think clearly, fall asleep, and manage pain. Factor 2 included sharp pain with movement, ability to go home with pain, and fear of movement. Factor loadings for the 8 items were greater than 0.40 and Cronbach's alpha was 0.75. A total score on the

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8-item pain instrument predicted pain intensity and interference, psychological distress, self-efficacy, opioid consumption, and LOS at hospital discharge and accounted for more variance in outcomes than VAS scores.

**Conclusions:** An 8-item multidimensional postoperative pain instrument was developed for use in patients with orthopaedic trauma. This tool has the potential to identify patients at risk for poor outcomes and who may benefit from more aggressive pain management. Additional research is needed to validate this instrument in other samples, assess the relationship to long-term pain, psychological, and functional outcomes, and create benchmarks that will guide clinicians in the treatment of traumatic postoperative pain.

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**Factors Affecting Pain in Acute Ankle Fractures: A Prospective Evaluation***David Saper, MD; Jody Litrenta, MD; Peters Otlans, MPH;**James Daley, MPH; Paul Tornetta, III, MD;**Boston University Medical Center, Boston, Massachusetts, USA*

**Purpose:** Pain has been identified as the dominant factor in patient outcomes. Early pain has also been demonstrated to predict long-term pain. Recent work has demonstrated that there may be differences in the way that different ethnic groups feel pain given similar noxious stimuli. The purpose of this study was to evaluate the degree of pain reported in a large series of acute ankle fractures and to determine what factors are associated with higher pain scores.

**Methods:** We prospectively evaluated 457 consecutive patients with acute Weber B supination external rotation (SE) ankle fractures upon presentation for pain in 9 areas of the ankle. There were 231 females and 226 males, average age 46.2 years (range, 18-96) with 133 bi-/trimalleolar and 324 lateral malleolar fractures (101 SE2, 73 stress (+) SE4, and 150 ligamentous SE4 injuries). There were 215 black, 160 white, and 82 Latino patients. The highest pain score (visual analog scale, 0-10) for the medial and lateral regions was chosen for analysis. We used a separate multivariate linear regression model to determine which factors correlated with reported pain medially and laterally. To determine the fracture parameters to include, we evaluated injury pattern (bony vs ligamentous, stable vs unstable, etc) with univariate analysis. The other factors included in the multivariate linear regression model were: age, ethnicity, diabetes mellitus, alcohol presence, and days from injury to presentation on the level of pain reported.

**Results:** In univariate analysis, neither the type of injury (medial malleolus or deltoid ligament) nor instability differed with respect to medial pain. However, patients presenting with instability had more lateral pain ( $5.6 \pm 3$ ) than those with stable injuries ( $2.6 \pm 3$ ) ( $P < 0.001$ ). Additionally, those with bony medial injury had more lateral pain ( $7 \pm 2.7$ ) than those with isolated lateral malleolar fractures ( $4.0 \pm 3.4$ ) ( $P < 0.001$ ). Finally, confirming other reports, the degree of medial pain for patients with stress (+) SE4 injuries was not different from those with SE2 injuries. Most important, in the multivariate analysis, the only factor that was significant for both medial and lateral pain (separate regressions) was ethnicity, with blacks having more pain given the same injury than whites ( $P < 0.001$ ). Latinos trended toward having more lateral pain than whites ( $P = 0.15$ ), but not more medial pain ( $P = 0.3$ ). For lateral pain, in addition to ethnicity, presence of a displaced mortise ( $P < 0.0001$ ), having a bony medial injury ( $P < 0.0001$ ), and the days from injury ( $P = 0.008$ ) were significant. Pain was greater for unstable injuries, those with instability, but decreased with time from injury.

**Conclusions:** Pain is an important factor in short- and long-term outcomes. In this evaluation of over 450 patients with a well-defined injury (Weber B, SE pattern ankle fractures), we confirmed previous work in the upper extremity indicating an important difference in the reported pain by ethnicity. In particular, black patients have more pain than white patients given the same injury, but Latino patients do not. This indicates that more attention to the initial pain management in black patients may be helpful in their overall outcomes. Additionally, this is the first study to demonstrate that unstable fractures and those with medial bony injuries have more lateral pain on presentation than do stable fractures and those without medial malleolar fractures.

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**The Orthopaedic Trauma Patient: Risk Factors Influencing Follow-up**

Vignesh K. Almanda, BS; Barry Kang, BS; Jesse Ehrenfeld, MD, MPH;  
William T. Obremsky, MD, MPH; Zachary Yoneda BS; Manish K. Sethi, MD;  
A. Alex Jahangir, MD;

Vanderbilt University Medical Center, Nashville, Tennessee, USA

**Background/Purpose:** Adherence to follow-up appointments has been cited as an important factor in improving patient outcomes throughout the literature. Optimal management of patients with orthopaedic trauma injuries often revolves around the ability of patients to follow up in clinic. However, no previous study has specifically evaluated the factors that influence follow-up in the care of the orthopaedic trauma patient. In the face of increasing scrutiny of healthcare cost and quality, it is critical to gain more insight into factors influencing follow-up as this is critical in identifying perioperative complications in the orthopaedic trauma population. The purpose of our study was to evaluate and identify specific factors influencing rates of follow-up in patients with orthopaedic trauma.

**Methods:** This retrospective study reviewed clinic visits for patients who were treated at a large academic Level I trauma center during a 1-year span between September 1, 2009 and September 1, 2010. For each patient, demographic data were collected, which including age, sex, ethnicity, tobacco and alcohol use, American Society of Anesthesiologists (ASA) score, insurance status, and distance from the hospital. Follow-up was categorized as either completing the visit (compliant) or cancelling or failing to show (noncompliant). Univariate analysis was performed to assess factors that affect compliance. A paired *t* test was used to analyze the impact of the distance between home and clinic.

**Results:** 11,463 appointments were analyzed for the 1-year span. Ethnicity was a significant factor affecting compliance. Compared with Caucasians, Asian-Americans were 26% more likely to follow up (~2980 more clinic visits) and Hispanic-Americans were 10% less likely to follow up (~1146 less clinic visits). Patients paying out of pocket demonstrated a 13% decrease in compliance (~1490 less clinic visits) when compared to patients with private insurance. Patients who reported smoking demonstrated a 6% decrease in compliance (~688 less clinic visits) on average when compared to non-tobacco users. For patients who underwent operative treatment, an increase of 1 in ASA score equates to a 6% decrease in compliance (~688 less clinic visits). The farther patients lived from clinic the less likely they were to be compliant with follow-up appointments. This was particularly significant for patients living 100 to 500 miles away who were 40% less likely to follow up (~4585 less clinic visits) than a person living less than 50 miles from the hospital ( $P < 0.05$ ).

**Conclusions:** Our study is the first of its kind to demonstrate clear factors among the orthopaedic trauma population influencing follow-up. We demonstrate that factors such as ethnicity, tobacco use, insurance status, ASA score, and distance from clinic play a crucial role in influencing compliance with follow-up appointments. By identifying these factors when patients first present to a trauma center with an orthopaedic injury, the healthcare team can identify patients who may be at risk for noncompliance and design a care plan that best maximizes follow-up.

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### Reliability of an Adaptive Computer-Based Patient Outcomes Scoring Tool in Orthopaedic Trauma Patients

*Brett D. Crist, MD; Gregory J. Della Rocca, MD, PhD; David A. Volgas, MD; James P. Stannard, MD; University of Missouri, Columbia, Missouri, USA*

**Purpose:** We sought to determine the reliability of a computer-based condensed patient-centered outcome score system versus multiple standard uncondensed validated outcome scores used in orthopaedic trauma.

**Methods:** A commercially available web-based clinical research and electronic medical records (EMR) program (Outcome-Based Electronic Research Database [OBERD]) was used to create a condensed version of the Musculoskeletal Functional Assessment (MFA), EuroQol 5D (EQ-5D), MPI/PDI (Multidimensional Pain Index/Pain Disability Index), and visual analog scale (VAS). The number of questions was decreased by removing redundant questions and using adaptive questioning to minimize the need for patients to answer irrelevant questions based on prior responses. This system allows for each questionnaire to be populated in its entirety while decreasing responder burden. It also decreases the risk of responder error by using visual aids and forced responses. To determine reliability, patients seen at a Level I hospital orthopaedic trauma outpatient clinic were asked to complete the computer-based questionnaire and complete the paper versions of the EQ-5D and MFA at different times to be able to compare the actual scores. Incomplete paper or computer-based surveys were not included.

**Results:** 100 patients completed both surveys. The average score difference between the computer-based and paper-based MFA was 0.5 with a standard deviation of 6.03 and a 95% confidence interval of -0.71 to 1.71. For the EQ-5D, the average score difference was 0.116 with a standard deviation of 0.2 and a 95% confidence interval of -0.0483 to 0.0483.

**Conclusions:** As patient-centered outcomes drive the direction of orthopaedic care, collecting patient data while minimizing responder burden will be critical. This condensed web-based adaptive outcome tool reliably produced similar scores when compared to individual paper scores while decreasing responder burden and error.

### **A Prospective Randomized Double-Blind Control Trial Assessing Patient Satisfaction in an Orthopaedic Trauma Population**

*Brent Morris, MD; Justin Richards, MD; Melissa Lasater, MSN, ACNP; Denise Rabalais, BA; Cindy Wedel, MPA; Ronald W. Hill, MPH; Manish K. Sethi, MD; A. Alex Jahangir, MD; Vanderbilt University Medical Center, Nashville, Tennessee, USA*

**Background/Purpose:** Patient satisfaction is a key determinant of quality of care and an important component of pay for performance metrics. There is a paucity of data in the orthopaedic literature assessing patient satisfaction, especially with regard to orthopaedic trauma patients. We are not aware of any studies looking at methods to improve the patient's understanding of the primary orthopaedic surgeon that is directing his or her orthopaedic trauma care in order to improve patient satisfaction. The purpose of our study was to evaluate the impact of a simple intervention that increases the patients' understanding of who their orthopaedic trauma surgeon is and the impact of this intervention on patient satisfaction.

**Methods:** Our pilot study was a double-blinded randomized control trial. Patients admitted to the orthopaedic trauma service at a single high-volume Level I trauma center and requiring operative intervention during the same hospitalization were computer randomized to a control or intervention group. Exclusion criteria included prior clinic visit, cognitive impairment, non-English speaking, or prior relationship with the surgeon. The intervention group received a biosketch card of his or her orthopaedic trauma surgeon while the control group did not receive a card. The biosketch card includes a picture of the attending orthopaedic trauma surgeon with a brief synopsis of his or her education background, specialty, surgical interests, research interests, and other interests including hobbies. A single research team member who had no involvement in the patient's clinical care distributed biosketch cards. Patients received a standardized telephone survey prior to the first clinic appointment to assess patient satisfaction with the care they received from their orthopaedic trauma surgeon. Patients, surgeons, and telephone surveyors were blinded to the nature of the study.

**Results:** Surveys were available from 81 patients. 34 of 81 completed surveys were randomized to the intervention (biosketch card); 47 of 81 were in the control group. Mean age for the control was  $41.50 \pm 15.80$  years compared to  $40.35 \pm 16.78$  years ( $P = 0.76$ ). Males comprised 61.7% of the control and 58.8% of the intervention ( $P = 0.79$ ). Mean length of stay (LOS) for the control was  $3.4 \pm 1.7$  days compared to  $3.4 \pm 1.5$  days ( $P = 0.95$ ). 25 of 34 patients (73.5%) who received a card reported "Excellent overall quality of doctor care," while only 26 of 47 (55.3%) with no card reported "Excellent care" ( $P = 0.09$ ). Male gender (32 of 51 [62.8%] vs 17 of 30 [56.7%];  $P = 0.59$ ), lack of insurance ( $P = 0.85$ ), LOS ( $3.13 \pm 1.61$  days vs  $3.55 \pm 1.65$  days;  $P = 0.27$ ), and attending surgeon ( $P = 0.9$ ) were not significant with reference to "Excellent" outcome.

**Conclusion:** Clinically significant improvements in overall reported satisfaction were identified in patients who received a biosketch card of their attending orthopaedic surgeon. 74% of patients receiving a biosketch card reported "Excellent overall quality of doctor care," compared to 55% in those who did not receive a card and there was no significant difference in gender, insurance status, LOS, or the attending surgeon. This study demonstrates that a simple intervention can result in an increase in patient satisfaction regarding their orthopaedic trauma care.

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### Is Patient Satisfaction Among Orthopaedic Trauma Patients Predicted by Patient Depression and Activation?

*Elisa J. Knutsen, MD<sup>1</sup>; Ebrahim Paryavi, MD, MPH<sup>1</sup>; Renan C. Castillo, PhD<sup>2</sup>;  
Robert V. O'Toole, MD<sup>1</sup>;*

*<sup>1</sup>R Adams Cowley Shock Trauma Center, Department of Orthopaedics,  
University of Maryland School of Medicine, Baltimore, Maryland, USA;*

*<sup>2</sup>Center for Injury Research & Policy, Johns Hopkins Bloomberg School of Public Health,  
Baltimore, Maryland, USA*

**Purpose:** Patient satisfaction (PS) is becoming an important metric in the assessment of quality of care. Among orthopaedic trauma patients, little is known about the relationship between PS and patient levels of depression or "activation," a term used to capture the level of involvement of a patient in their care. Our hypothesis was that a patient's level of satisfaction is correlated to their levels of depression and activation.

**Methods:** Our study group included 124 patients with at least one fracture treated at a Level I trauma center. Patients were evaluated  $\geq 6$  weeks from injury in orthopaedic trauma clinics. Outcome measures were the Patient Satisfaction Questionnaire (PSQ); the Patient Activation Measure (PAM), which measures a patient's "activation" level or their participation in their health care; and the Patient Health Questionnaire (PHQ-9), which is a screening and evaluation tool for presence and severity of depression. Spearman correlation coefficients were used to assess the relationship between activation level and depression severity with PSQ domains. Bivariate and multivariate linear regression models were used to determine the independent effects of depression and activation on general satisfaction.

**Results:** PS was moderate to high both in general (mean 4.17, 97% confidence interval [CI] 4.02, 4.32), as well as in the domains for technical quality, interpersonal manner, communication, and time spent with doctor (mean scores were 4.36, 4.46, 4.52, 4.02, respectively). Satisfaction was lower for the domains of financial aspects and accessibility and convenience (mean 3.54, 3.80). Spearman correlation coefficients were high for patient activation and all PSQ domains (generally over 0.3 and  $P < 0.05$ ). Correlation coefficients were weaker for depression and PSQ domains ( $\rho$  ranged from 0.16 to 0.33). A final multivariate linear regression model demonstrated an improvement in general satisfaction of 0.14 (95% CI 0.05, 0.237) with increasing patient activation. We also found a decrease in general satisfaction  $-0.028$  (95% CI  $-0.051, -0.005$ ) with increasing PHQ-9 depression score.

**Conclusions:** These data suggest that patient satisfaction is strongly correlated with patient "activation" but less correlated with presence of depression. This opens up the possibility that patient satisfaction after orthopaedic trauma might be improved by encouraging and coaching patients on how to be more invested and involved in their own health care.

## The Prevalence and Costs of Defensive Medicine Among Orthopaedic Trauma Surgeons: A National Survey Study

Manish K. Sethi, MD; Vasanth Sathiyakumar, BS; William T. Obremskey, MD, MPH; Hassan R. Mir, MD; A. Alex Jahangir, MD; Vanderbilt University Medical Center; Nashville, Tennessee, USA

**Background/Purpose:** Defensive medicine is defined as medical practices that may exonerate physicians from liability without significant benefit to patients. Many studies have argued that defensive medicine is a major cost driver in health care; however, the national prevalence of defensive medicine in the field of orthopaedic trauma surgery has not been investigated. The purpose of this study is to investigate the practice of defensive medicine and the resultant financial implications of such behavior by orthopaedic trauma surgeons in the United States.

**Methods:** In September of 2010, 2000 orthopaedic surgeons randomly chosen from the AAOS registry received invitations to answer a web-based survey on defensive medicine. Of these, 1214 (61%) completed the survey. 216 (18%) of those who completed the survey identified themselves as orthopaedic trauma surgeons. Cost analysis was performed using Center for Medicare and Medicaid Services (CMS) data, which were provided at the 2011 CPT code level and then aggregated to reflect the eight domains of care assessed in this study.

**Results:** Of the 216 orthopaedic trauma surgeon respondents, on average, 27% of all ordered tests were for defensive reasons (radiography, 22%; CT scanning, 20%; MRI, 31%; ultrasound, 44%; referrals, 31%; laboratory tests, 21%; and biopsies, 21%). Defensive hospital admissions averaged 7% each month. While orthopaedic trauma surgeons reported ordering more radiographs and CT scans than the overall study population, likely due to the nature of the subspecialty ( $P < 0.005$ ), the proportion of tests ordered for defensive reasons by orthopaedic trauma surgeons was similar to the overall study population. Using the average national Medicare payment information from the 2011 CPT code reimbursement data, the cost of defensive medicine per respondent was calculated to be approximately \$8400 monthly or approximately \$100,000 per year, which is roughly 22% of each physician's spending. Given that there are approximately 900 orthopaedic trauma surgeons in active practice in the United States according to the OTA, this study estimated that the national cost of defensive medicine for the subspecialty of orthopaedic trauma surgery is \$7.5 million per month and \$90 million annually.

**Conclusion:** Defensive medicine among orthopaedic trauma surgeons is a significant factor in healthcare costs and of marginal benefit to patients. Policies aimed at managing liability risk may be useful in containing such practices.

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**The Homeless Orthopaedic Trauma Patient: Issues With Follow-up**

Vasanth Sathiyakumar, BS; Jake J. Porter III, MPH; Adedapo Ajayi, BS;  
William T. Obrensky, MD, MPH; Jesse Ehrenfeld, MD, MPH; Mallory Powell, BA;  
A. Alex Jahangir, MD; Manish K. Sethi, MD;  
Vanderbilt University Medical Center, Nashville, Tennessee, USA

**Background/Purpose:** Homelessness presents many challenges for patients who have sustained orthopaedic injuries. Homeless patients have many complex social, nutritional, and long-term management issues that often exacerbate injuries and increase complications such as infections and failures of treatment. Furthermore, these patients are often uninsured and are believed to have high emergency department (ED) utilization. However, no study has documented the issues associated with orthopaedic trauma treatment of homeless patients and their follow-up rates. The purpose of this study is to review homeless patients with orthopaedic trauma injuries and examine ED utilization, follow-up rates, and ancillary support systems such as nutritional support and social work, and complication rates among other factors.

**Methods:** Through chart review from 2001 to 2010, 65 patients were identified as uninsured, homeless patients with orthopaedic trauma injuries. Patients were identified as homeless if the patient listed a homeless shelter within a 30-mile radius of Vanderbilt University Medical Center as their address and / or if they were identified as homeless on the ED intake sheet. These charts were evaluated to determine management of injury, ED and orthopaedic specialty clinic visits and follow-up rates, complications, and involvement of social work and nutritional support. 150 uninsured, non-homeless patients with orthopaedic trauma injuries were randomly selected as controls. Statistical significance was analyzed utilizing analysis of variance and *t* tests.

**Results:** After the index visit to the ED for their orthopaedic trauma injury, homeless patients were more likely to subsequently visit the ED for follow-up care of the index injury, with 21% of all subsequent visits for homeless patients occurring in the ED compared with 0% of follow-up visits for control patients ( $P < 0.0001$ ). Additionally, homeless patients were much less likely to follow up in clinic than controls, with homeless patients presenting to 49% of their scheduled appointments compared with control patients who had an 82% follow-up rate ( $P < 0.0001$ ). Social workers were more involved with homeless patients, with 63% of homeless patients receiving a social work consult compared with 47% of control patients. There was a negligible difference in nutritional support consultation between the two groups (39% of homeless patients compared with 41% of control patients). Finally, the overall complication rate between homeless patients and control patients was not significantly different, with each group averaging a 21% complication rate.

**Conclusion:** Our data are the first to examine the problems associated with homelessness in the orthopaedic trauma patient and demonstrate an increased challenge in follow-up care. The orthopaedic surgeon must consider these issues in managing this complex patient population and put in place processes, such as improving social work and nutritional consults, in the treatment of this challenging population. Improved protocols to manage the homeless patient can result in better outcomes and patient care.

See pages 97 - 144 for financial disclosure information.



## Can External Fixators Be Sterilized for Surgery? A Prospective Cohort Study in Orthopaedic Trauma Patients

David Hardski, MD<sup>1</sup>; Richard Venezia, MD<sup>2</sup>; Jason W. Nascone, MD<sup>1</sup>;  
Marcus F. Sciadini, MD<sup>1</sup>; Robert V. O'Toole MD<sup>1</sup>;

<sup>1</sup>R A Cowley Shock Trauma Center, Department of Orthopaedics, University of Maryland  
School of Medicine, Baltimore, Maryland, USA;

<sup>2</sup>University of Maryland Medical Center, Baltimore, Maryland, USA

**Purpose:** Previous basic science research has raised concern about the ability of surgical preps to sterilize external fixators that have already been applied to patients at the time of staged surgery. To our knowledge, no investigators have addressed this issue in actual patients. Our hypothesis was that our institution's standard surgical prep practice would create a low rate of culture-positive environments on external fixators at the time of skin incision.

**Methods:** After IRB approval, patients returning to the operating room with external fixators already in place at the surgical site were consented for study participation. All components of the external fixator were wiped with 70% alcohol-soaked sterile 4 × 4 gauze sponges prior to skin prep. The skin and external fixator were then prepped with ChlorPrep (Carefusion) or a povidone iodine prep and paint for open wounds. Immediately prior to the skin incision, swab cultures were taken from three locations: the most distal pin, the most distal bar at the midpoint between the pin-to-clamp connectors, and the most distal clamp at the bar-clamp interface. The swabs were processed in a research laboratory using standardized protocol and the results were not made available to clinicians or patients at any time. Our prospective study yielded 36 culture results from 12 external fixators. Six patients had high-energy open fractures and three patients had open wounds at the time of the culture. Five patients (42%) came from home, while the rest were still inpatients from their initial injury. The mean time from initial external fixator placement to culture was 12.8 days (range, 2-44). All were from lower extremity fractures.

**Results:** Only 1 of 36 cultures was positive, yielding a prep failure rate of 2.8% (95% confidence interval: 0.5-14.2%, Wilson approach). The only positive culture came from the clamp swab in an individual who had the external fixator in place for 17 days and was admitted from home for definitive fixation of a closed pilon fracture. The speciation of the culture showed *Staphylococcus epidermidis*. The patient's postoperative course has not been complicated by infection.

**Conclusions:** Our prep protocol of first using 70% alcohol on external fixators followed by either ChlorPrep or a povidone iodine scrub appears to result in a relatively low rate (2.8%) of positive cultures on external fixators. These data are in direct contrast to the basic science data that showed significant bacterial growth using povidone iodine prep in a testing model that immersed external fixators in a solution containing coagulase-negative staphylococcus. Our data indicate that this prep protocol may be reasonably effective at producing a sterile environment at the time of surgery in patients with external fixators already in place.

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### Do Smokers Know Smoking Is Bad for Fracture Healing?

*Paul E. Matuszewski, MD; Robert V. O'Toole, MD; Christina L. Boulton, MD;  
R Adams Cowley Shock Trauma Center, Department of Orthopaedics,  
University of Maryland School of Medicine, Baltimore, Maryland, USA*

**Background/Purpose:** Multiple studies have shown that smoking is associated with increased complications in fracture care, including increased infection rate, wound healing difficulties, and perioperative morbidity. Recent data also demonstrate that smoking cessation may have a positive impact on fracture care. It is unknown what knowledge fracture patients possess regarding the effects of smoking as well as their interest in smoking cessation. The hypotheses of this study are that (1) smokers less fully understand smoking's negative effects than nonsmokers, and (2) simple education on the negative effects of smoking and fracture outcomes can influence a patient's reported desire to quit smoking.

**Methods:** All patients presenting to our orthopaedic trauma clinic within 8 weeks of injury were surveyed ( $n = 78$ , 48 nonsmokers and 30 smokers, 44 males and 34 females). Patients having sustained a new extremity or pelvis fracture were included in the study. Nonsmokers were defined as those patients who have never smoked or have not smoked in the last 6 months. A 24-question survey was administered to each patient with questions relating to demographics, knowledge questions about smoking's effect on health and fracture care, and opinion questions assessing decisional balance in smoking. Additionally, the survey addressed the smoking patients' willingness to quit by measuring the previously defined transtheoretical stage of change before and after survey administration. Finally, we determined patients' interest in receiving materials/interventions to aide in smoking cessation. Categorical variables were compared using the Fisher exact test.

**Results:** On average, smokers answered 90% more knowledge questions incorrectly than their nonsmoking counterparts (19% vs 10% incorrect;  $P < 0.05$ ). 12% of smokers modified their stage of change closer towards quitting after survey administration ( $P < 0.05$ ). In addition, 37% of smokers stated that their injury by itself increased their interest in quitting, whereas almost half (47%) stated that the administration of our survey increased their interest in quitting smoking. Patients were queried in regards to their interest to receive one or more of four interventions (information, nicotine patches, pharmacological therapy, and behavioral therapy). Patients were interested in receiving an average of 1 to 2 smoking cessation interventions and 57% of smokers were interested in receiving at least one intervention.

**Conclusion:** The smoking public appears to be less aware than the nonsmoking public regarding the negative effect of smoking on fracture outcomes. Even the simple administration of this survey in the orthopaedic surgeon's clinic appeared to influence patients' desire to quit smoking. It is possible that the orthopaedic trauma surgeon may play an important role in smoking cessation for these patients. Further studies should be aimed at which smoking cessation interventions are efficacious in injured patients and how they can best be initiated in the orthopaedic clinic.

### **Predictors of Need for In-Patient Rehabilitation Post Surgery for Lower Extremity Injury (RADI Pilot Project)**

*Dominique Rouleau, MD, FRCSC, MSc<sup>1</sup>; Alexandre Place, BSc<sup>2</sup>;*

*George-Yves Laflamme, MD, FRCSC<sup>1</sup>; Debbie Feldman, PhD<sup>2</sup>;*

*<sup>1</sup>Hôpital du Sacré-Coeur de Montréal, Université de Montréal, Montreal, Quebec, Canada;*

*<sup>2</sup>Université de Montréal, Montreal, Quebec, Canada*

**Purpose:** No method currently exists to differentiate between patients who are able to return home quickly from those who will require a stay in a rehabilitation or convalescence center post surgery for lower extremity injury. Clarification of the risk factors for in-patient rehabilitation or convalescence will allow the rapid identification of patients who will require additional resources. At the moment a multidisciplinary evaluation that requires a large amount of time is necessary to determine patient orientation.

**Methods:** Our prospective study of hospitalized patients at a tertiary trauma center seeks to determine which characteristics of the patient, his or her living environment, the trauma, and the treatments received affect postoperative needs. To accomplish this, quality-of-life questionnaires (Lower Extremity Measure [LEM], Short Form 12 v2 [SF-12], demographic information) referring to pretrauma status and a physical test (Timed Up and Go [TUG]) were administered to patients within 48 hours after their orthopaedic treatment. The TUG was repeated at 7 days post surgery or at discharge (if this occurred before 7 days). Student *t* tests were used to compare mean lengths of hospital stay between groups. An odds ratio (OR) calculation was used to verify the association between dichotomic variables (for example rehabilitation vs return home).

**Results:** 48 patients accepted to participate in the study (mean age, 53 years; 44% female). Mean TUG score at 48 hours was 61.7 s (seconds) and 62.8 s at discharge or at 7 days postoperatively. The mean score on the pretrauma LEM was 93.8. The SF-12 physical component summary (PCS) scale mean score was 50.7 and mental component summary (MCS) score was 51.3. Hospital stay was significantly ( $P = 0.0004$ ) longer in patients who required convalescence/rehabilitation (16 days) compared to those who returned home directly (7 days). The following variables were associated with increased length of hospital stay: TUG completion impossible at 48 hours postoperatively, polytrauma, and accompanying injury of the upper-limbs. Similarly, polytrauma (OR 3.3), bilateral lower limb injuries (OR 11), co-occurring upper limb injuries (OR 3.3), and use of a walking aid before the injury (OR 5) increased the risk of requiring admission to a rehabilitation or convalescence center. Age, living environment, and the mechanism of injury were not associated with admission to in-patient rehabilitation or convalescence.

**Conclusion:** Being unable to complete the TUG at 48 hours postoperatively and having suffered a polytrauma, especially with an upper limb injury, increases hospital stay length post surgery for lower extremity injury. Having an increased length of hospital stay was associated with requirement for rehabilitation/convalescence. This is partially explained by the time necessary for finding an available rehabilitation facility. Having suffered bilateral lower extremity trauma, concomitant upper limb injury and polytrauma increase the risk

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of needing rehabilitation by 3 to 11 times and should trigger planning for rehabilitation arrangements at the moment of admission in acute care. This preliminary study is the first step in gathering the necessary data to allow the creation of a score predicting the need for rehabilitation/convalescence after a trauma of the lower limbs.

## A Ten-Year Analysis of the Orthopaedic Trauma Association Research Funding Program

Mitchell Bernstein, MD<sup>1</sup>; Nicholas M. Desy, MD<sup>1</sup>; Bogdan A. Matache<sup>2</sup>;

Todd O. McKinley, MD<sup>3</sup>; Edward J. Harvey, MD, MSc, FRCSC<sup>1</sup>;

<sup>1</sup>Division of Orthopaedic Surgery, Montreal General Hospital, McGill University Health Center, Montreal, Quebec, Canada;

<sup>2</sup>Faculty of Medicine, McGill University, Montreal, Quebec, Canada;

<sup>3</sup>Department of Orthopaedics and Rehabilitation, University of Iowa Hospitals and Clinics, Iowa City, Iowa, USA

**Background/Purpose:** The OTA established a research funding program in 1990. Through competitive grant applications, the OTA funds clinical and basic science projects conducted by residents and faculty. The funding amounts are significantly smaller than other granting agencies. Performance characteristics of the program have yet to be fully examined. We sought to determine if a subspecialty society has the capability to direct their research by comparing their output with other agencies. We also aimed to identify various research parameters that could affect grant success.

**Methods:** Grants were identified through the OTA online archive. The title of each grant and the principal investigator's name were used to search across seven scientific databases for associated publications. A similar protocol identified any abstracts presented at three major orthopaedic meetings. Information was also sought through direct contact through the OTA directorate. The data were sorted based on the type of research divided into three categories: resident, faculty basic science (basic science), or faculty clinical (clinical).

**Results:** From 2000 to 2009, \$3,507,050 was awarded through 131 grants: 59 resident, 39 basic science, and 33 clinical. There were 202 publications: 45 resident, 84 basic science, and 73 clinical. 41% of resident grants were published, compared with 80% basic science and 67% clinical. The likelihood of a grant being published was 3.85 times higher if it was a basic science project compared with a resident ( $P = 0.008$ ; confidence interval [CI]: 1.41-10.49); however, clinical studies were not predictive of publication success compared with basic science or resident projects. The cost per resident publication was \$13,111 compared with \$13,353 for basic science and \$24,594 for clinical. There was no relationship between the amount funded and the likelihood of the project being published. The mean impact factor (MIF) per publication for resident, basic science, and clinical were similar (2.4 vs 3.3 vs 2.6;  $P = 0.189$ ). 49% of resident abstracts were presented at a national meeting versus 77% of basic science and 61% clinical. If the project was presented at a meeting, it is 10.4 times more likely to be published ( $P = 0.000015$ ; CI: 3.59-30.18).

**Conclusion:** Over the study period, the publication output for funded projects was substantial. Faculty-directed basic science studies had the highest publication rate. All three groups published in similar impact peer-reviewed journals. The MIF for all groups was 2.9, which is comparable to the National Institutes of Health (NIH) (MIF = 5.5) and the American College of Gastroenterology (MIF = 6.7), considering that the MIF for orthopaedic journals

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is 1.4. The mean cost per publication was \$17,712, which appears substantially lower than the NIH cost. The OTA is an important source of orthopaedic trauma research funding.

Category	Grants awarded	Publications	% Grants published	Cost per publication	MIF	% Abstracts Presented
Resident	59	45	41	\$13,111	2.4	49
Basic Science	39	84	80	\$13,353	3.3	77
Clinical	33	73	67	\$24,594	2.6	61

**Adequacy of Musculoskeletal Education Among Emergency Medicine Physicians***Garet C. Comer, MD; Emily Liang; Julius A. Bishop, MD;**Stanford University Medical Center, Palo Alto, California, USA*

**Background/Purpose:** Emergency medicine physicians are frequently responsible for evaluating and treating patients with urgent or emergent musculoskeletal conditions, so it is critical that they achieve a basic level of proficiency in musculoskeletal medicine. However, inadequacies in musculoskeletal education have previously been documented among medical students, as well as residents and attending physicians, in a number of specialties. The goal of this study was to assess the proficiency with musculoskeletal medicine among emergency medicine physicians in particular.

**Methods:** A validated musculoskeletal medicine competency examination was administered to the emergency medicine residents and faculty at a university-affiliated Level I trauma center. Demographic data, experience with common orthopaedic procedures, and satisfaction with musculoskeletal education were also surveyed.

**Results:** 20 emergency medicine residents and 21 attending physicians completed the survey. 35% of residents and 43% of attending physicians failed the examination. Pass rates were not significantly different among junior residents, senior residents, or attending physicians. 23% of respondents indicated that they were dissatisfied with their musculoskeletal education.

**Conclusion:** Significant deficiencies in musculoskeletal education exist among emergency medicine physicians at all levels of training. Given the frequency with which these physicians evaluate and treat acute musculoskeletal conditions, additional resources should be committed to their training.

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## Improving Decision-Making in Fracture Care: Cognitive Bias and Rational Choice

*Jaimo Ahn, MD, PhD; Joseph Bernstein, MD;*

*University of Pennsylvania, Philadelphia, Pennsylvania, USA*

**Purpose:** We sought to determine if known cognitive biases can result in irrational responses when patients consider treatment options for fracture-related care.

**Methods:** A survey was presented to 131 subjects: five clinical scenarios describing a tibial plateau fracture were provided, and respondents were asked to select among treatments offered. Four weeks later, the scenarios were presented again, with slight modifications: (1) To test for an anchoring bias, the respondents were asked to state the maximal rate of surgical complications they would accept; but in the second iteration, an artificially high value was suggested to them. (2) To test for a peer bias, the respondents were first asked to choose between arthroscopic and open treatment; and when it was seen after the first iteration that arthroscopy was favored, in the second iteration, they were told that most people would choose open surgery. (3) To test for a framing bias, respondents were asked twice to choose between surgery and therapy to correct arthrofibrosis: in the first instance, surgery was presented as a means of gaining motion relative to the postfracture state; whereas in the second instance, surgery was presented as a means of preventing loss of motion relative to the prefracture state. (4) To test for an emotional valence bias, respondents were asked if they would prefer a prophylactic fasciotomy to prevent a compartment syndrome, but in the second instance were they shown photographs of necrotic muscle and an amputation. (5) Finally, to test for a distraction bias, respondents were first asked to select between strong or weak anticoagulants, with offsetting benefits; but in the second iteration, they were presented with the same two choices plus a third and obviously inferior choice—a strong anticoagulant with high risk of complication, which, although not appealing itself, makes the original strong anticoagulant appear more appealing in comparison.

**Results:** In all cases, cognitive biases led to response inconsistencies, as shown in the table below.

Scenario	First Iteration	Second Iteration
1. Maximal acceptable complication rate	Baseline: Mean response = 19%	When told that 78% was reasonable: Mean response = 32%
2. Open vs minimally invasive surgery	Baseline: Open surgery = 4%	When told that open was chosen by 85%: Open surgery = 18%
3. Surgery vs therapy for arthrofibrosis	Baseline (as potential gain): Surgery = 40%	When told surgery is means to avoid loss: Surgery = 60%
4. Prevention of compartment syndrome	Baseline information only: Fasciotomy = 42%	When shown complication pictures as well: Fasciotomy = 72%
5. Deep vein thrombosis prevention	Strong anticoagulant = 25% Weak anticoagulant = 75%	Inferior strong anticoagulant = 0% Strong anticoagulant = 43% Weak anticoagulant = 57%

See pages 97 - 144 for financial disclosure information.



**Conclusions:** The selection among treatment options in fracture management can utilize an expected-value calculation. For each option, patients can consider the possible outcomes, likelihood of attaining these outcomes, and values they place on them. Rational choice dictates that the option with the greatest expected value should be selected. Yet our data indicate the potential for irrational choices when patients contemplate fracture management options. If true patient-centered care is to be offered, surgeons need to be aware of the cognitive biases that lead to irrational decision-making.

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**The Incidence of Death Following Outpatient Management of Fractures:  
Is Fatal Pulmonary Embolism a Common Clinical Problem?***Dan E. Deakin, FRCS; Christopher G. Moran, MD;**University Hospital Nottingham, Nottingham, United Kingdom*

**Purpose:** Orthopaedic surgeons are increasingly pressured to consider thromboprophylaxis for patients when little evidence exists. The aim of this study was to determine the incidence of fatal pulmonary embolism following attendance in orthopaedic fracture clinic.

**Methods:** Between October 2004 and September 2006, details of all new patients attending our fracture clinic were prospectively entered into an audit database. Patients did not receive any form of thromboprophylaxis. Data was cross-referenced with the office of national statistics to identify all patients who subsequently died within 90 days of being seen in fracture clinic.

**Results:** 11,502 new patient fracture clinic appointments occurred during the study period. 5604 patients had lower limb injuries. 23 patients died within 90 days of being seen. The mean age of these patients was 75 years (range, 52-100). Two of the 23 patients attended fracture clinic with lower limb injuries. Review of the medical records showed no evidence of pulmonary embolism. Assuming a worst case scenario that both died of fatal pulmonary embolism, the incidence of fatal pulmonary embolism following attendance in fracture clinic with a lower limb injury is no higher than 0.036% (95% confidence interval, 0.09%-0.33%).

**Conclusion:** The incidence of fatal pulmonary embolism following outpatient management of lower limb fractures is very low. This incidence data will inform decisions on the risk-benefit analysis of thromboprophylaxis in this group of patients.

## CT Angiography in Lower Extremity Trauma Does Not Change Management Without Corresponding Physical Examination Findings

Thomas Fishler, MD; Michael P. Leslie, DO;

Yale-New Haven Hospital, New Haven, Connecticut, USA

**Purpose:** Traumatic vascular injury in the extremities can be devastating, yet diagnosis of such injuries remains a challenge. The most significant diagnostic advance in the past decade has been the development of computed tomographic angiography (CTA) as an alternative to conventional angiography (CA) to make the imaging diagnosis of vascular injury. Unlike CA, which requires a specially skilled interventionalist team, CTA can be performed by technologists trained in conventional CT. While easy to obtain, CTA remains a costly procedure. We hypothesized that CTA was overutilized in our population.

**Methods:** A retrospective review of all CTA studies of the lower extremities in trauma patients from January 2006 through December 2010 was performed at a Level I trauma center. Approval by our IRB was obtained. 41 studies in 41 patients were identified by searching our imaging database by study type, date, and patients' status as modified or full trauma. Individual patient charts were then examined for injury type, CTA results, subsequent vascular imaging (primarily CA), and vascular intervention, whether surgical repair or medical anticoagulation.

**Results:** The table below summarizes our results. Of 40 diagnostic studies, 56% were positive for some abnormal finding. However, only 10 of these went on to any specific treatment for their vascular injury, with surgical repair or bypass performed in 9 and anticoagulation alone used to treat an intimal injury in 1. Strikingly, all 10 of these patients had either a pulseless foot or an ankle-brachial index of <0.9, while none of the remaining patients had either finding on clinical examination.

**Conclusion:** Our study shows that utilization of CTA as a screening method for vascular injury can lead to a high rate of abnormal findings of minimal significance, which do not alter patient management.

Mean age	34 ( $\pm$ 12)
Male gender	36
Blunt mechanism	26
Fracture / dislocation	31
Diagnostic studies	40
Abnormal CTA	23 (56%)
Follow-up imaging (CA or Doppler)	4
Correlation of follow-up imaging with CTA	3 (75%)
Open vascular repair	9
Anticoagulation without surgery	1
Change in management prompted by abnormal CTA	10/23 (43%)

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### Use of the Multiple Listing Service to Obtain Surrogate Socioeconomic Data in Orthopaedic Trauma Patients

*Ebrahim Paryavi, MD, MPH<sup>1</sup>; Renan C. Castillo, PhD<sup>2</sup>;*

*<sup>1</sup>R Adams Cowley Shock Trauma Center, Department of Orthopaedics, University of Maryland Medical School, Baltimore, Maryland, USA;*

*<sup>2</sup>Center for Injury Research & Policy, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA*

**Background/Purpose:** Patient socioeconomic status (SES) is often a confounding factor for both patient-reported and clinical outcomes. SES data are critical for the appropriate interpretation of outcome metrics and the availability is often limited in orthopaedic trauma research. The current gold-standard for obtaining SES data is direct, patient-reported household or personal income and level of education. We hypothesized that median property value in proximity of a patient's reported address, obtained from a regional realtors' multiple listing service (MLS) database, can be used as a proxy for SES.

**Methods:** A survey of 150 patients presenting to an orthopaedic clinic at a Level I trauma center after an extremity fracture was performed to obtain household income, size, and level of education. Patients' home addresses were obtained from the medical record. The Metropolitan Regional Information Systems' (MRIS) online MLS database was queried for median property values on the street of each patient's recorded address from listings in the past 5 years. Missing median property values (28 patients) were imputed from census data using median income and poverty level by zip code. Spearman correlation coefficients were determined for the relationship between log-transformed property value from the MLS and patient-reported SES covariates (income, household size, education). Bivariate logistic regression was used to determine the relationship between property value and poverty and college education level. Ordinal logistic regression of SES covariates on property value was used to examine the predictive ability of our surrogate SES factor in determining income and education level.

**Results:** Spearman's rho values for the relationship between MLS property value and income and education level were high at 0.45 and 0.26, respectively ( $P < 0.01$ ). The odds ratio for poverty was 0.33 (95% confidence interval [CI]: 0.17, 0.65) with increasing log-transformed property value. The odds of having at least some college education were 2.13 (95% CI: 1.22, 3.69) times higher with increasing log-transformed property value. We found that each unit increase in log-transformed property value increased the expected ordered log odds of a higher income bracket and education level by 1.19 (95% CI: 0.71, 1.67) and 0.72 (95% CI: 0.27, 1.17), respectively.

**Conclusion:** Median property value proximate to patients' home addresses obtained from an MLS database can be a reliable surrogate for income and education level. This method addresses the lack of SES data, which is a key limitation of many retrospective chart review studies. Further studies are needed to determine if this method of approximating SES data can be used to control for SES as a confounder in orthopaedic trauma outcomes studies.

**Early Evaluation of the Trauma Survivors Network at a Major Level I Trauma Center**

*Renan C. Castillo, PhD<sup>1</sup>; Stephen T. Wegener, PhD<sup>2</sup>; Mary Zadnik Newell, ScD, Med, OTR/L<sup>1</sup>; Anthony R. Carlini, MS<sup>1</sup>; Anna N. Bradford, MSW<sup>1</sup>; Sara E. Heins, BA<sup>1</sup>; Elizabeth Wysocki, MS<sup>3</sup>; Andrew N. Pollak, MD<sup>3</sup>; Harry M. Teter, JD<sup>4</sup>; Ellen J. MacKenzie, PhD<sup>1</sup>;*

*<sup>1</sup>Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA;*

*<sup>2</sup>Johns Hopkins Medicine, Baltimore, Maryland, USA;*

*<sup>3</sup>University of Maryland Medical School, Baltimore, Maryland, USA;*

*<sup>4</sup>American Trauma Society, Upper Marlboro, Maryland, USA*

**Purpose:** The Trauma Survivors Network (TSN) is a multimodal program for patients and their family members designed to help them manage the psychosocial impact of their injury and enhance recovery. It combines timely access to information for patients and families, self-management training, peer support, and online social networking into a comprehensive program provided to patients from acute care throughout recovery. The purpose of this study is to evaluate the effectiveness of the TSN in improving patient reported outcomes among orthopaedic trauma patients at a Level I trauma center.

**Methods:** This was a historical control observational cohort study at a large, urban Level I trauma center. We prospectively enrolled 251 patients suffering from either severe lower extremity injuries or polytrauma, in two cohorts. One cohort was enrolled between 2008 and 2009 prior to the implementation of the TSN program (n = 125). A second cohort was enrolled between 2009 and 2010 following the initial rollout of the program (n = 126). Participants were enrolled and interviewed during their initial hospital stay and followed by phone at 6 months. Participation in the individual components of the TSN was voluntary and was not required for participation in the research study. Participants were evaluated at 6 months for depression (Patient Health Questionnaire, which classifies patients as having probable depression if total score is >9), anxiety (Brief Symptom Inventory), self-efficacy (General Self-Efficacy Scale), and function (Short Form [SF]-12). The 6-month follow-up rate was 78%.

**Results:** Participation in the individual components of the TSN was low, ranging between 2% for the NextSteps self-management program and 29% for receipt of the Patient and Family Handbook. There were no differences between treatment and control groups in self-efficacy, anxiety, and function. There were statistically significant differences in depression (23.9% of patients with probable depression in TSN group vs 40.2% in control group,  $P = 0.02$ ). However, the groups were not balanced with respect to gender (greater number of females in the control group), education (higher percent with some college in the treatment group), and baseline social support as measured by the Multidimensional Scale of Perceived Social Support (higher social support in the treatment group). After adjusting for these sociodemographic differences between the groups using logistic regression analysis, the TSN group still had 44% lower odds of depression (95% confidence interval: 72% lower to 14% higher), although these differences were no longer statistically significant ( $P = 0.11$ ).

**Conclusion:** The TSN represents a potentially important step toward the development of comprehensive psychosocial support programs for trauma survivors. A key finding of this

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evaluation is the low rate of utilization of the program components. This low utilization reflects the need for greater understanding of barriers to patient utilization and the need for program efforts to increase adoption among trauma survivors. However, given the improvement in one important outcome and the low utilization rates, the positive impact observed may reflect beneficial nonspecific effects associated with adoption of the program or that patients most likely to benefit preferentially accessed the available resources.

### **Teamwork in Trauma: System Adjustment to a Protocol for Management of Multiply Injured Patients**

*Heather A. Vallier, MD; Timothy A. Moore, MD; Andrea J. Dolenc, BS; John J. Como, MD; Michael P. Steinmetz, MD; Karl G. Wagner, MD; Charles E. Smith, MD; Patricia A. Wilczewski, RN, BSN; MetroHealth Medical Center, Cleveland, Ohio, USA*

**Background/Purpose:** Fixation of mechanically unstable fractures of the femur, pelvis, acetabulum, and spine decreases pain and promotes mobility from a recumbent position, both of which reduce pulmonary complications. We developed a protocol to determine timing of definitive fracture care based on the adequacy of resuscitation. Inception of this project required a multidisciplinary group, including physicians from anesthesia, general trauma critical care, neurosurgery, orthopaedic spine, and orthopaedic trauma. The protocol recommends definitive fixation of these fractures within 36 hours of injury, based on laboratory parameters for acidosis. The purposes of this study were to review our initial experience with adherence to protocol recommendations and to assess barriers to implementation.

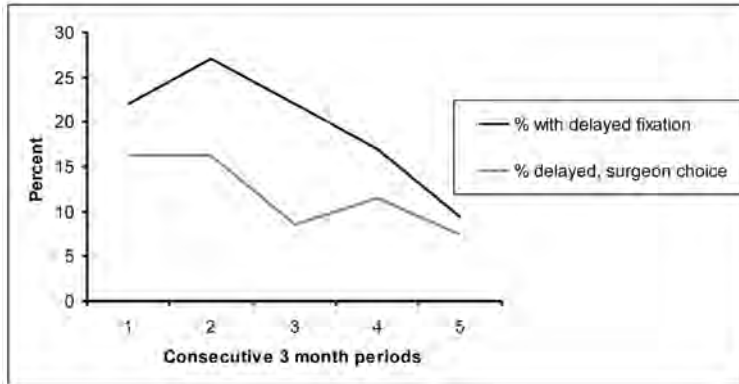
**Methods:** 209 consecutive skeletally mature patients with ISS >16 (mean 27.0) and 236 fractures of the proximal or diaphyseal femur (n = 98), pelvic ring (n = 40), acetabulum (n = 27), and/or spine (n = 71) were treated surgically from October 2010 through December 2011 at a Level I trauma center by 6 spine surgeons and 7 orthopaedic trauma surgeons, all experienced in spine and pelvis/acetabulum trauma, respectively. Adherence to the protocol was defined as definitive fixation within 36 hours of injury in resuscitated patients and damage control surgery in underresuscitated patients. Patients who were resuscitated but did not have fixation within 36 hours were defined as delayed. Patient demographic and injury characteristics, date and time of presentation, and reasons for delay were recorded.

**Results:** Three patients (1.4%) had definitive fixation of a fracture before being deemed adequately resuscitated. 164 patients (79%) with 186 fractures were treated according to the protocol, while 42 patients (20%) with 45 fractures (19%) were definitively stabilized on a delayed basis (mean 90 hours), although they met protocol clearance, including 26 spine (37%), 11 pelvis (28%), 4 acetabulum (15%), and 4 femur fractures (4.1%). Before the protocol, over 7 years our hospital treated 76% of these patients on a delayed basis, demonstrating improvement for each fracture type: spine (79% of previous patients with delay), pelvis (57%), acetabulum (72%), and femur (22%) (all  $P < 0.0001$  for more frequent delayed surgery before the protocol). Surgeon choice to delay the procedure accounted for 59% of the reasons for delay. Other reasons included intensivist choice (15%), operating room availability (8.7%), patient choice (4.3%), and other (8.7%). Our trauma center and surgeons became more accustomed to the protocol and had fewer delays over time. Delay was not related to patient age, ISS, or week day or time of presentation.

**Conclusion:** Management of trauma patients with injury to multiple systems requires teamwork among providers from related specialties and hospital support, in terms of operating room access, with appropriate ancillary personnel and equipment. Our system adjusted quickly to the protocol, with delayed surgery in less than half of those in our historical ex-

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perience. Surgeon preference was the most common reason for delayed fixation, but within 15 months less than 10% of fractures were treated on a delayed basis, as long as patients were resuscitated. Expediting surgical care in stable patients should decrease complications, length of stay, and treatment costs.





**Predictive Ability of the Orthopaedic Trauma Association Open Fracture Classification***Richard B. Barber, MD<sup>1</sup>; Julie Agel, ATC<sup>2</sup>; Todd Rockwood, PhD<sup>3</sup>;**<sup>1</sup>Christus Spohn Memorial Hospital, Corpus Christi, Texas, USA;**<sup>2</sup>Harborview Medical Center, Department of Orthopaedics, Seattle, Washington, USA;**<sup>3</sup>University of Minnesota, Division of Health Policy & Management, Minneapolis, Minnesota, USA*

**Background/Purpose:** The OTA Classification Committee developed an Open Fracture Classification designed to provide clinicians with standardized terminology that could be applied to all open fractures regardless of location and not susceptible to changes in treatment technology. The variables that comprise this classification are: Skin, Muscle Injury, Bone Loss, Arterial Injury, and Contamination. Each variable has three values in increasing order of severity. The purpose of this project was to determine if the variables that compromise this classification are predictors of clinical treatment.

**Methods:** 185 fractures with open wounds on the lower leg were seen between November 1, 2010 and December 31, 2011 at a Level I trauma center. The classification of these open fractures was completed as part of routine registry data collection by the trauma fellows involved with each patient's care. Patients' records were reviewed to determine if the patient underwent an amputation, had a vacuum-assisted closure (VAC) applied, or antibiotic beads placed. In addition the number of débridements the patient underwent were categorized as  $\leq 2$  or  $> 2$ . 13 patients underwent an amputation, 45 had a VAC, 12 had antibiotic bead placement, and 27 had more than 2 débridements. Using logistic regression we created models of all variable combinations to determine which model had the best predictive value of the independent variables of interest. Guttman scales were created to demonstrate the contribution by value for each variable that had the independent variable of interest.

**Results:** For patients undergoing amputation, skin was the single most significant predictor (odds ratio [OR] 4.0; 95% confidence interval [CI] 1.4, 11.7; Wald  $\chi^2$   $P$  0.01). The equation that was most predictive of amputation contained all five variables but was similar in predictive value to that of using just Skin, Contamination, Arterial or Skin, contamination, Arterial and Bone or Skin, Contamination, Arterial, and Muscle. For patients who had a VAC skin (OR 2.6; 95% CI 1.4, 4.8; Wald  $\chi^2$   $P$  0.01) was the single most significant predictor by more than double the next variable (Arterial). The equation that explained the most variance contained all five variables. For patients who underwent antibiotic bead placement, bone loss (15.7; OR 6.2; 95% CI 1.6, 23.8; Wald  $\chi^2$   $P$  0.01) was the single most significant predictor by more than double the next variable (skin). The equation that explained the most variance contained Skin, Arterial, Muscle, and Bone. For patients with more than 2 débridements, Skin (24.1; OR 2.7; 95% CI 1.4, 5.4; Wald  $\chi^2$   $P$  0.01) was the single most significant predictor by more than double the next variable (Muscle). The equation that explained the most variance contained was Skin, Contamination, Arterial, Muscle, and Bone. However, the difference between using all five variables and Skin, Muscle, and Bone alone was negligible.

**Conclusion:** The predictive value of this classification for the independent variables evaluated in this project in the lower extremity is clinically logical and statistically significant.

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**The Cost of Saying Yes: Hand Transfers to a Level I Trauma Center**

*Lauren N. Hinojosa, MD; Kelly E. Cline, MD; Gregory Ford, RN; Adam J. Starr, MD; Department of Orthopaedic Surgery, University of Texas Southwestern Medical Center, Dallas, Texas, USA*

**Purpose:** This review was undertaken to investigate patients transferred to a Level I trauma center for hand injury management.

**Methods:** Hand trauma patients transferred to our Level I trauma center were identified using our transfer hotline database and hospital records over a 27-month period. We retrospectively reviewed charts to determine method of transfer, distance of transfer, types of injuries encountered, patient insurance status, and accuracy of the transferring physician's description of the injury. We documented management at our hospital, patient disposition, and nonreimbursed charges from our hospital.

**Results:** 460 patients with hand trauma were transferred to our center in the study period. 84% were male and average age was 38 years (range, 14-92). The most common injuries encountered were: 30.2% traumatic amputations, 22.6% infection, and 21.1% fractures (open and closed). Most patients were transported via ground ambulance (80%). Other methods included 7% private vehicle, 5% by air transport, and 8% an unknown mode of transportation. Average distance of the transfer was 51 miles (range, 0.2-402 miles). 273 patients (59%) were transferred from out of county. 10 patients crossed state lines to reach our hospital. Virtually all patients had to bypass another Level I trauma center en route to our center. The description of injury given by the transferring provider correlated with our diagnosis 72.8% of the time. 48% of the patients were treated and discharged directly from our emergency department. 48.7% had some form of insurance coverage, including 21.5% private insurance, 14.8% workers' compensation, 7.4% Medicare, and 5% Medicaid. Unpaid charges from uninsured hand trauma patients (51.3%) during the study period totaled \$2,853,033.45.

**Conclusion:** Any CMS (Centers for Medicare & Medicaid Services) participatory hospital that has specialized capabilities or facilities may not refuse to accept a patient in transfer, if it has the capacity to treat the individual [42 USC 1395dd(g); 42 CFR 489.24(f)]. Our Level I trauma center has provided hand trauma care for many years. Our data suggest that surrounding centers are abusing this service. Widespread regional lack of hand trauma services results in a shifting of the burden of care to the few hospitals that offer such service. This lack of care also burdens patients with added expense and time brought about by transfer. The transferring physician accurately described most hand trauma patients transferred to our center. Half were treated and discharged from our emergency room. This indicates some may have been potentially manageable in a clinic setting, likely at a lower cost. Further research is needed to identify methods to remove barriers to provision of care for hand trauma patients.

### Who Needs an Orthopaedic Trauma Surgeon? An Analysis of U.S. National Injury Patterns

*R. Carter Clement, BSE; Michael J. Kallan, MS; Brendan G. Carr, MD;*

*Patrick M. Reilly, MD; Samir Mehta, MD;*

*University of Pennsylvania Department of Orthopaedics, Philadelphia, Pennsylvania, USA*

**Purpose:** Many hospitals in the United States are seeking to gain and maintain trauma credentialing. Assessment of trauma center success has traditionally focused on mortality without directed measure of surgical subspecialization. However, survival alone may not be a sufficient marker of success within modern health care if a substantial volume of trauma management involves subspecialty care. The purpose of this study was to determine the number of trauma patients nationally who would benefit from subspecialized care by an orthopaedic traumatologist.

**Methods:** A list of musculoskeletal ICD-9 codes consistent with injuries managed by those with subspecialty training in orthopaedic traumatology was generated. Using the 2006 National Inpatient Sample (NIS) data set, we estimated the nationwide volume of three groups of patients: (1) the total number of adult trauma patients with an identifiable injury (ISS score 1-75) and known mortality status, (2) the number of trauma patients sustaining musculoskeletal injury, and (3) the number of trauma patients requiring an orthopaedic traumatologist or subspecialty orthopaedic trauma care as defined by ICD-9 code.

**Results:** In 2006, 2,068,349 patients sustained a traumatic injury. Nearly half (46.7%, [966,415]) of all trauma patients had an orthopaedic injury and 25.7% (536,132) sustained an injury requiring the attention of an orthopaedic traumatologist.

**Conclusion:** Analysis of nationwide data reveals that over one-quarter of trauma patients sustain an orthopaedic injury that, if resources permit, should be seen by a fellowship-trained orthopaedic traumatologist. Given this substantial volume, detailed outcome measures, beyond mortality, need to be developed to assess trauma patients who sustain musculoskeletal injury. Additionally, resources, including fellowship training in orthopaedic trauma, should be allocated in a methodical manner that matches supply to national demand for this type of care.

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**Short-Handed: The Lack of Hand Coverage in South Central USA**

*Lauren N. Hinojosa, MD; Timothy Brown, MD; Sheena R. Black, MD; Sheri Glaser, BSN; Marissa Daniels, BA; Adam J. Starr, MD; Department of Orthopaedic Surgery, University of Texas Southwestern Medical Center, Dallas, Texas, USA*

**Purpose:** Our objective was to evaluate the availability of hand surgeons taking call for emergency rooms in Texas, Louisiana, and Oklahoma.

**Methods:** Hospitals in all three states were identified from state trauma system rosters, and from online searches. Hospitals with emergency rooms (ERs) were identified. ER providers in these hospitals were contacted by telephone and queried with a survey regarding availability of hand surgeons, and management of patients presenting to ERs with hand complaints.

**Results:** We completed our survey in 345 of 490 hospitals (70%). 244 (71%) had no hand coverage available. Complete coverage (24 hours a day, 7 days per week) was available in only 16% (55 of 345), and of these hospitals with complete coverage, 63% (35 of 55) still transferred out some hand trauma patients. 52.6% of Level I trauma centers transfer out hand trauma patients. In 203 (59%) of the hospitals, hand trauma patients were expected to arrange their own follow-up with a hand specialist. Non-hand surgeon ER providers responded as follows regarding injuries they manage themselves: 96% would manage simple hand lacerations (no tendon, nerve, or vessel involvement), 95% would splint a simple closed fracture, 90% would treat a nail bed injury, 66% would manage a tuft fracture of a distal phalanx, and 52% would manage an amputation distal to the distal interphalangeal joint. Only 7.5% of ER providers had received additional training on hand injury management postresidency.

**Conclusion:** Most ERs in Texas, Louisiana, and Oklahoma do not have a hand surgeon available. Most hand trauma patients who present to an ER—even an ER in a medium-sized city—should expect to be transferred to another city, or another state. Most ER physicians have received little training in management of hand trauma, and they feel forced to care for hand trauma patients without the necessary skills. These are remarkable findings. Our study reveals that for most hospitals in Texas, Louisiana, and Oklahoma, the problem with hand trauma management is not that it is delayed, or incomplete, or poorly done. The problem is that hand trauma management is not offered *at all*. Injuries to the hand can be crippling, especially for young laborers. This problem deserves further research, to develop systems to bypass barriers to care for hand trauma patients.

**Occupational Injury Among Orthopaedic Surgeons: A Lack of Resources***William T. Davis, BS; A. Alex Jahangir, MD; Mallory Powell, BA;**William T. Obrensky, MD, MPH; Manish K. Sethi, MD;**Vanderbilt University Medical Center, Nashville, Tennessee, USA*

**Background/Purpose:** Occupational injury is an important issue that has never been studied in orthopaedic surgeons. Orthopaedic surgery is a physically demanding profession that requires many hours per week in positions known to contribute to musculoskeletal injury and pain. Demand for orthopaedic services is expected to grow at an exponential pace, and surgeon injury can affect the delivery of timely and sufficient care, placing a greater strain on the healthcare system and providers. Furthermore, physician injury can have large economic consequences to the healthcare system and providers due to the investments of training, personnel, and overhead in each surgeon. This is the first study of its kind to gather fundamental data and evaluate occupational injury among orthopaedic surgeons.

**Methods:** Electronic surveys were distributed via e-mail to all orthopaedic surgeons in Tennessee.

**Results:** 131 of 495 surveys (25%) were returned, with representation from all orthopaedic subspecialties. On average, respondents were 50 years old, had 20 years of surgical experience, and performed surgery for 18 hours per week. 41% of respondents reported suffering one or more injuries in the operating room. Injuries were sustained in the following areas: hand (25%), lower back (18%), neck (11%), shoulder (8%), and other (6%). Among injured surgeons, 33% responded that they had no institutional resources or support for occupational injuries. 43% of individuals reporting an injury received medical treatment, 29% reported the injury to their institution, and 25% missed work due to injury, with 10% missing at least 3 weeks.

**Conclusions:** Our study is the first of its kind to demonstrate that occupational injury occurs at a high rate among orthopaedic surgeons. Given the 33% of respondents reporting no institutional support for occupational injuries, it is clear that closer attention must be paid to this issue. Our study shows that occupational injury leads to missed work in many surgeons and a significant percentage of injured surgeons miss work for at least 3 weeks. The volume of work missed suggests that occupational injury has potentially large economic implications for the healthcare system and providers. The pervasiveness of missed work due to occupational injury warrants a large-scale study of the orthopaedic surgeon population into the nature of injuries suffered, factors that predispose surgeons to injury, and interventions to lower the risk of occupational injury.

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**Orthopaedic Surgeons' Knowledge and Attitudes in the Clinical Identification of Intimate Partner Violence Against Women: A Survey of Surgeon Members of the OTA**

**Gregory J. Della Rocca, MD, PhD, FACS<sup>1</sup>; Sheila Sprague, MSc<sup>2</sup>; Sonia Dosanjh, MSW<sup>2</sup>; Emil H. Schemitsch, MD, MSc, FRCS(C)<sup>3</sup>; Mohit Bhandari, MD, PhD, FRCSC<sup>2</sup>;**

<sup>1</sup>*Department of Orthopaedic Surgery, University of Missouri, Columbia, Missouri, USA;*

<sup>2</sup>*Division of Orthopaedic Surgery and the Departments of Surgery and of Clinical Epidemiology and Biostatistics, McMaster University, Hamilton, Ontario, Canada;*

<sup>3</sup>*Division of Orthopaedics, Department of Surgery, University of Toronto, St. Michael's Hospital, Toronto, Ontario, Canada*

**Purpose:** We aimed to identify the knowledge, attitudes, and beliefs about intimate partner violence (IPV) against women among orthopaedic surgeons who are members of the OTA.

**Methods:** We surveyed members of the OTA by posting a survey on the OTA web site for its membership to complete. The survey consisted of three sections: (1) the general attitude of the orthopaedic surgeon toward IPV, (2) the attitude of the orthopaedic surgeon toward victims and batterers, and (3) the clinical relevance of IPV in orthopaedic surgery.

**Results:** Of the 153 respondents, the majority were male (90%), with practices in North America (96%). Surgeons underestimated the prevalence of IPV in their practices and communities and manifested several key misconceptions: (1) victims must be getting something out of the abusive relationships (16%), (2) some women have personalities that cause the abuse (20%), and (3) the battering would stop if the batterer quit abusing alcohol (40%). In the past year, approximately half of the surgeons (50.8%) acknowledged identification of a victim of IPV; however, only 4.0% of respondents currently screened for IPV among female patients with injuries. Surgeons expressed concerns about lack of knowledge in the management of abused women (30%). Guidelines for the detection and management of IPV were uncommon in most surgeons' practices (7.8%).

**Conclusion:** Our study found that orthopaedic surgeons underestimated the prevalence of IPV, held multiple misperceptions about IPV, and demonstrated discomfort in identifying and treating IPV. Targeted educational programs on IPV are needed for surgeons who routinely care for injured women.

**Risk of Hospital Readmission in Orthopaedic Trauma:  
Using Electronic Medical Records to Improve Quality of Care**

*Holman Chan, MD; Catherine A. Humphrey, MD; Jonathan M. Gross, MD, MPH;  
John P. Ketz, MD; John Gorczyca, MD;  
Strong Memorial Hospital, Rochester, New York, USA*

**Purpose:** The purpose of this study is to identify patient risk factors for unplanned hospital readmission in orthopaedic trauma using electronic medical records (EMR) as a method of monitoring institutional complication rates. We hypothesized that orthopaedic trauma patients have common medical comorbidities and social attributes unique to this population that place them at risk for hospital readmission. Secondly, we believe that EMR is an effective quality assurance tool to evaluate institutional patient complications.

**Methods:** Using EMR, charts of all adult patients admitted to a Level I academic trauma hospital with a surgical orthopaedic injury were reviewed to identify those patients who were readmitted subsequent to their initial event. Readmission was defined as a return to hospital for diagnoses related to the initial orthopaedic trauma and/or surgery. Demographic information of this patient subset, including age, gender, and premorbid medical and surgical conditions, was tabulated. Data from social history included use of tobacco, alcohol, and recreational drugs in addition to their social level of function. Univariate analysis was performed to test for significance in patient risk factors.

**Results:** The readmission rate for the orthopaedic trauma division at a Level I trauma hospital in 2011 was 39 of 1095 patients (3.6%). The mean age of the 39 readmitted patients was 51 years compared to 45 years for those with only one admission ( $P = 0.04$ ). Common diagnoses of these patients at their initial admission include lower extremity trauma (28 of 39 [72%]), open fractures (11 of 39 [28%]), and polytrauma (12 of 39 [31%]). 12 of 39 patients (31%) were readmitted within 6 weeks of discharge, and 26 of 39 (67%) within 6 months of discharge. The primary diagnoses for readmission were infection (44%), nonunion/malunion (25%), and medical-related (19%) such as thromboembolism and uncontrolled pain. Statistically significant preexisting conditions associated with readmission were tobacco use (relative risk [RR] 6.2,  $P = 0.0001$ ), obesity (RR 4.9,  $P = 0.01$ ), hypertension (RR 4.7,  $P = 0.0001$ ), and a psychiatric disorder (RR 4.6,  $P = 0.0008$ ). Open tibial shaft fractures were the strongest predictors of readmission (RR 14,  $P = 0.003$ ). In 2011, 20 open tibial shaft fractures were seen by the orthopaedic trauma division, with 8 of these patients returning with a complication: 5 infections, 2 nonunions, and 1 soft-tissue contracture.

**Conclusion:** The preliminary results of this study demonstrate that orthopaedic trauma patients with specific comorbidities and injuries, such as cigarette smoking and open tibia fractures, are at a greater risk for hospital readmission. EMR is a recent advance and a powerful tool that can provide baseline quality-of-care data to traumatologists to effect change and improve patient outcomes.

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**The Influence of Body Mass Index on the Clinical Course of Multiple Trauma Patients***Frank Hildebrand, MD<sup>1</sup>; Hagen Andruszkow, MD<sup>1</sup>; Juliane Veh<sup>1</sup>;**Christian Krettek, MD<sup>1</sup>; Michael Frink, MD<sup>2</sup>;**<sup>1</sup>Trauma Department, Hannover Medical School, Hannover, Germany;**<sup>2</sup>Trauma Department, Hand and Reconstructive Surgery Unit, University of Marburg, Marburg, Germany*

**Background/Purpose:** Overweight and adiposity are well-characterized risk factors for the development of chronic diseases, such as diabetes and hypertension. Furthermore, patients with severe underweight represent a medical high-risk group. Little is known about the effects of weight on the incidence of posttraumatic complications. We therefore performed a retrospective study to investigate the association between body mass index (BMI) and the clinical course and outcome after multiple trauma.

**Methods:** Multiple trauma patients (ISS >16) admitted to our Level I trauma center between January 2005 and July 2011 were included in this study. Further inclusion criteria were admittance in our trauma center within 24 hours after trauma and age >16 years. Patients with incomplete medical records were excluded. Demographic data, clinical course, and BMI were documented. Multiple organ dysfunction syndrome (MODS) was defined according to the Marshall score, acute respiratory distress syndrome (ARDS) according to the American-European consensus conference, and sepsis according to the ACCP (American College of Chest Physicians)/SCCM (Society of Critical Care Medicine) criteria.

**Results:** 660 multiple trauma patients were included in this study. According to the BMI classification, 4.8% of included patients were underweight, 45.2% had normal weight, 36.0% were overweight, and 14.0% were adipose. Injury distribution showed a lower incidence of traumatic brain injury in adipose patients, whereas overall injury severity demonstrated no association with BMI. Duration of mechanical ventilation and treatment on intensive care unit was significantly longer in patients with a high BMI. Besides injury severity (odds ratio [OR] 1.054;  $P = 0.001$ ) and APACHE II score (OR 1.059;  $P = 0.047$ ), multivariate analysis revealed the highest risk for development MODS for adipose patients (OR 4.209;  $P = 0.006$ ). A trend toward higher mortality was found in underweight patients. Furthermore, no significant differences for the incidence of SIRS (systemic inflammatory response syndrome), sepsis and ARDS were found between the analyzed groups.

**Conclusion:** BMI influenced injury distribution but not injury severity. Adiposity represents a relevant risk factor for the development of posttraumatic MODS. Therefore, specific treatment strategies have to be developed that consider the higher risk potential. This might include the use of "damage control orthopaedics," which reduces the burden of initial surgery. Furthermore, patients with underweight seem to have a higher mortality. This has to be confirmed in studies with a higher number of included patients.



### Preoperative Lactate Does Not Predict Pulmonary Complications in Multiple Trauma Patients With a Femoral Shaft Fracture Treated With Early Total Care

Justin E. Richards, MD<sup>1</sup>; Sean M. Griffin, MD<sup>2</sup>; Daniel M. Koehler, BS<sup>1</sup>; Michael J. Bosse, MD<sup>2</sup>; William T. Obremsky, MD, MPH<sup>1</sup>; Jason M. Evans, MD<sup>1</sup>;

<sup>1</sup>Vanderbilt University Medical Center, Nashville, Tennessee, USA;

<sup>2</sup>Carolinas Medical Center, Charlotte, North Carolina, USA

**Background/Purpose:** Early Total Care (<24 hours) of femoral shaft fractures with a reamed intramedullary nail (IMN) has been shown to result in reduced morbidity and mortality. Occult hypoperfusion at the time of fracture fixation is thought to be associated with increased complications, and therefore serum lactate is often used as a marker of resuscitation. The purpose of this study was to evaluate the relationship of preoperative serum lactate and pulmonary complications in multiple trauma patients with a femoral shaft fracture who were treated with Early Total Care.

**Methods:** This was a retrospective investigation over a 5-year period from two academic Level I trauma centers. Inclusion criteria were age  $\geq 18$  years, ISS  $\geq 17$ , and femoral shaft fracture (OTA 32) treated within 24 hours with a reamed IMN. Demographic, injury characteristics, and hospital course data were collected from the trauma registry. Admission and preoperative serum lactate values were obtained from the medical record. Occult hypoperfusion was defined as a preoperative lactate  $\geq 2.5$  mmol/L. Time to fracture fixation was categorized as  $>12$  hours or  $\leq 12$  hours. The primary outcome was pulmonary complications (PC): pneumonia, tracheostomy, duration of mechanical ventilation  $>4$  days. Initial 24-hour packed red blood cell (PRBC) transfusion, IMN estimated blood loss (EBL), and duration of mechanical ventilation (vent days) were also recorded.

**Results:** 73 patients met criteria for study inclusion with a mean ISS of 25.7 (range, 17-50). 56 patients (76.7%) had a preoperative lactate  $<2.5$  mmol/L and 17 of 73 (23.3%) had occult hypoperfusion at the time of femoral fracture fixation. ISS was similar among preoperative lactate groups ( $26.2 \pm 7.2$  vs  $24.11 \pm 7.2$ , respectively;  $P = 0.24$ ). 38 patients (52.1%) underwent fixation in  $\leq 12$  hours; patients who received a reamed IMN in  $\leq 12$  hours were more likely to have occult hypoperfusion (13 of 17 [76.5%] vs 25 of 56 [44.6%];  $P = 0.02$ ). There was no difference in ISS and time to fracture fixation ( $25.3 \pm 7.1$  vs  $26.1 \pm 7.4$ ,  $P = 0.65$ ). There was no difference in Emergency Department Glasgow Coma Scale (ED GCS) scores among lactate groups ( $12.4 \pm 4.7$  vs  $10.9 \pm 5.2$ ;  $P = 0.29$ ) or timing of fracture fixation ( $11.2 \pm 5.3$  vs  $11.3 \pm 4.9$ ;  $P = 0.93$ ). There was no difference in the frequency of occult hypoperfusion and PC (2 of 17 [11.8%] vs 12 of 56 [21.4%];  $P = 0.38$ ), PRBC ( $2.3 \pm 3.6$  units vs  $1.4 \pm 2.4$  units;  $P = 0.22$ ), IMN EBL ( $352.9 \pm 191.0$  cm<sup>3</sup> vs  $300.9 \pm 181.7$  cm<sup>3</sup>;  $P = 0.31$ ), or vent days ( $2.1 \pm 4.7$  days vs  $2.5 \pm 4.0$  days;  $P = 0.68$ ). ED GCS was not significantly associated with PC ( $8.6 \pm 5.9$  vs  $11.8 \pm 4.7$ ;  $P = 0.05$ ). Similarly, there was no difference in time of fracture fixation ( $\leq 12$  hours) and PC (5 of 38 [13.2%] vs 9 of 35 [25.7%];  $P = 0.17$ ); however, vent days were significantly less in patients treated within 12 hours ( $1.5 \pm 2.9$  days vs  $3.5 \pm 5.1$  days;  $P = 0.04$ ).

**Conclusion:** Use of Early Total Care with a reamed IMN in polytraumatized patients with a femoral shaft fracture was not associated with increased pulmonary complications despite

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evidence of occult hypoperfusion. Future studies are necessary to further delineate the role and degree of resuscitation that is most optimal in the multiply injured orthopaedic trauma patient.

**Critical Care Benefits of Rib Fracture Fixation: A Meta-Analysis**

*Gerard Slobogean, MD, MPH, FRCSC; Terri Sun, BSc; Cailan MacPherson, MD, MHSc; Morad Hameed, MD, MPH, FRCSC; University of British Columbia, Vancouver, British Columbia, Canada*

**Purpose:** As members of the trauma team and experts in fracture care, orthopaedic surgeons are taking an active role in the surgical management of flail chest injuries. Several small studies have suggested large improvements in critical care outcomes following surgical fixation of the multiple rib fractures. The purpose of the current study is to compare the results of surgical fixation and nonoperative management for flail chest injuries.

**Methods:** A systematic review of previously published studies comparing operative and nonoperative management of flail chest was performed. No language or date restrictions were applied. Quantitative pooling was performed using a random-effects model for relevant critical care outcomes. Sensitivity analysis was performed for all outcomes.

**Results:** 11 manuscripts with 753 subjects met inclusion criteria. Only two studies were randomized control designs. Surgical fixation resulted in better outcomes for all pooled analyses including substantial decreases in ventilator days (mean 8 days, 95% confidence interval [CI] 5-10 days, Figure 1) and the odds of developing pneumonia (odds ratio [OR] 0.18, 95% CI 0.11-0.32, Figure 2). Additional benefits included decreased ICU days (mean 5 days, 95% CI 2-8 days), mortality (OR 0.31, 95% CI 0.20-0.48), septicemia (OR 0.36, 95% CI 0.19-0.71), tracheostomy (OR 0.06, 95% CI 0.02-0.20), and chest deformity (OR 0.11, 95% CI 0.02-0.60). All results were stable to basic sensitivity analysis.

POSTER ABSTRACTS

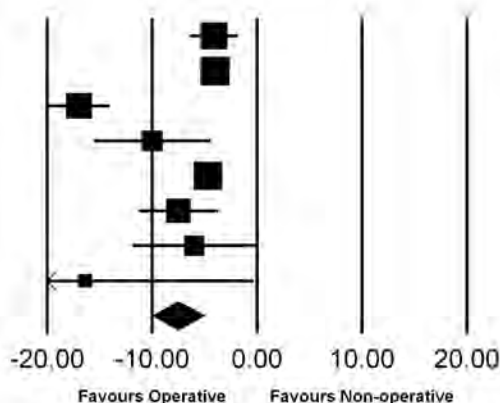


Figure 1 Mean difference in ventilator days

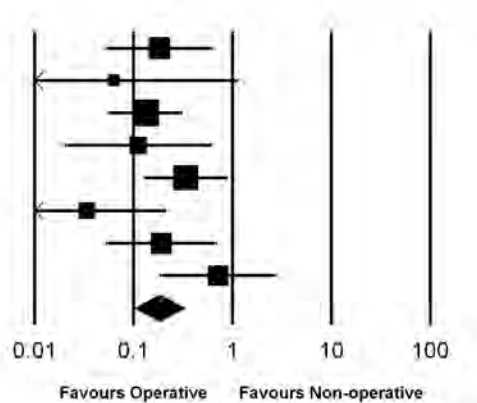


Figure 2 Odds ratio for developing pneumonia

**Conclusions:** As fracture care experts, orthopaedic surgeons can play an active role in the surgical fixation of flail chest injuries. The results of this meta-analysis suggest rib fracture fixation results in substantial critical care benefits; however, the analyses are based on the pooling of primarily small retrospective studies. Additional prospective randomized trials are still necessary and ongoing.

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**Increased Morbidity and Mortality After Bilateral Femoral Shaft Fractures?**

*Philipp Kobbe, MD, PhD<sup>1</sup>; Fabian Micansky<sup>1</sup>; Philipp Lichte, MD<sup>1</sup>; Richard M. Sellei, MD<sup>1</sup>; Roman Pfeifer, MD<sup>1</sup>; Derek G. Dombroski, MD<sup>2</sup>; Rolf Lefering, PhD<sup>3</sup>; Hans-Christoph Pape, MD<sup>1</sup>;*

*<sup>1</sup>Department of Orthopaedic Trauma Surgery, University Hospital RWTH, Aachen, Germany;*

*<sup>2</sup>Parkland Health and Hospital System, Department of Orthopaedic Surgery, Dallas, Texas, USA;*

*<sup>3</sup>Institute for Research in Operative Medicine, Cologne Merheim Medical Center (CMMC), University of Witten-Herdecke, Witten, Germany*

**Background/Purpose:** Bilateral femoral shaft fractures have been reported to be an independent risk factor for morbidity and mortality; however, the value of these studies is limited due to small samples sizes and the timing of these studies before the establishment of damage control orthopaedics. The objective of this study was to compare the incidence of morbidity and mortality in patients with bilateral versus unilateral femoral shaft fractures.

**Methods:** This was a retrospective analysis of the German Trauma Registry from 2002 to 2005. Inclusion criteria were uni- or bilateral femoral shaft fractures and complete demographic data documentation. Univariate data analysis and logistic regression analysis were performed with SPSS.

**Results:** Between 2002 and 2005, 776 patients with unilateral and 118 patients with bilateral femoral shaft fractures were identified. Patients with bilateral femoral shaft fractures had a significantly higher ISS (29.5 vs 25.7 points), a significantly higher incidence of pulmonary (34.7% vs 20.6%) and multiple organ failure (25% vs 14.6%), as well as a significantly higher mortality rate (16.9% vs 9.4%). In the overall patient population, ETC (early total care) was significantly more often performed in patients with unilateral femoral shaft fractures (50.9% vs 33.6%). Logistic regression analysis revealed no significant correlation between bilateral femoral shaft fractures and multiple organ failure or mortality; however, bilateral femoral shaft fractures are an independent risk factor for pulmonary organ failure. Within a subgroup analysis, it was revealed that the impact of the bilateral femoral shaft fracture was especially pronounced in the subgroup with an ISS <25 points.

**Conclusions:** Bilateral femoral shaft fractures are still an independent risk factor for pulmonary organ failure but not for multiple organ failure or mortality. The impact of the additional femoral shaft fracture for pulmonary organ failure appears to be especially pronounced in the less severely injured patients, whose injuries are often underestimated when stratified with the ISS. Patients with bilateral femoral shaft fractures have significantly more often severe abdominal injuries as well as severe blood loss, which may account for the increased mortality rate. Therefore, the presence of bilateral femoral shaft fractures should be recognized as an increased risk for systemic complications.

**Operative Stabilization of Rib Fractures: Initial Experiences and Clinical Outcomes**

*Benjamin C. Taylor, MD; Bruce G. French, MD; Attila Poka, MD; Michael Principe, DO; Grant Medical Center, Columbus, Ohio, USA*

**Purpose:** This study was undertaken to critically assess and review the initial series of patients undergoing operative stabilization of rib fractures at an urban trauma center. We hypothesized that this procedure would be safe, with minimal perioperative complications. In addition, we hypothesized that pain relief would be reliable, with prompt recovery of thoracic and shoulder muscle function.

**Methods:** 27 patients who underwent operative fixation of rib fractures at our hospital by two fellowship-trained orthopaedic traumatologists were reviewed at greater than 6 months postoperatively. Demographic variables, injury characteristics, perioperative variables, and postoperative follow-up data were collected. Patients were then contacted to assess outcomes with the Oxford Shoulder Score questionnaire, McGill Pain questionnaire, and Baseline Dyspnea Index. Institutional board review was obtained prior to starting the study.

**Results:** At an average of  $10.06 \pm 4.0$  months, all patients had successful outcomes, with all involved rib fractures going on to union at an average of  $3.16 \pm 0.85$  months postoperatively. No wound breakdown or hardware prominence was noted, but one postoperative pulmonary embolus was seen. In all cases, chest symmetry was reestablished, with successful eradication of all paradoxical chest wall movement. Oxford Shoulder Scores were a mean of  $44.42 \pm 2.73$ , with Baseline Dyspnea Index scores  $9.57 \pm 1.50$ . McGill Short Form Pain Scores were  $2.43 \pm 0.65$ , with the Visual Analog Pain Scale at final follow-up at  $1.96 \pm 1.77$ . Range of motion of the shoulder returned to a functional level by 3 months postoperatively in 26 of 27 patients. All patients reported subjective pleasure with the results and all noted that they would undergo the procedure again.

**Conclusions:** Our initial experiences with this procedure are encouraging, and outcomes appear to correlate with previously published positive reports on this technique. In addition, the learning curve for this procedure appears to be minimal, with only a small trend in decreasing time per surgical case over the length of the study. The outcomes reported here show only mild residual pulmonary and musculoskeletal dysfunction after open reduction and internal fixation of rib fractures, with minimal perioperative complication rates.

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### Which Injuries Below the Knee Joint Affect the Late Outcome in Patients With Multiple Injuries?

Roman Pfeifer, MD; Philipp Kobbe, MD, PhD; Richard M. Sellei, MD;

Matthias Knobe, MD; Hans-Christoph Pape, MD;

RWTH Aachen University, University Clinic Aachen, Department of Trauma Surgery, Aachen, Germany

**Purpose:** Limited outcome after fractures below the knee joint is well known. However, it is unclear which injuries are responsible. We analyzed these injuries in a cohort of patients with multiple fractures.

**Methods:** Inclusion criteria were fractures below the knee joint, ISS  $\geq 16$  points, and follow-up  $>10$  years. Exclusion criteria were incomplete data, and patients  $>60$  and  $<3$  years of age. Clinical parameters were local pain, limp, instability, scores (Short Form-12, Rehabilitation Score), and functional results (walking distance, range of motion). Disability and retirement were recorded. All injuries were assessed classified according to their exact anatomic localization.

**Results:** 167 patients met the inclusion criteria. Mean was age 27.5 years (range, 3-55), 75% male, ISS 19.6 points (range, 16-50), follow-up 17 years (range, 10-29). Outcomes were pain in 63%, limping 45.2%, instability 31.7%, retirement 20.4%. *Outcome in patients with isolated fractures below the knee joint (n = 113, 67.7%):* In comparison to other fractures, patients with proximal tibia fractures were more frequently associated with chronic pain (80%,  $P = 0.002$ ). Functional disabilities (pain associated with stair-climbing and housework) were more frequently reported by patients who sustained proximal tibia fractures (73.3% and 60%) and patients with foot injuries (78.6% and 64.3%) ( $P < 0.05$ ). Limb-length differences were more frequently measured in patients with tibia shaft fractures (37.3%) and distal tibia fractures (28%) ( $P < 0.05$ ).

**Conclusion:** Worse functional outcome was common in patients with injuries of the proximal tibia and of the midfoot. Leg-length discrepancy was more commonly observed in tibia shaft and distal tibia fractures. Soft-tissue coverage seems to play a major role in these difficult injuries.

**Funding:** This study was supported by Hannover Re-Insurance.

### Volume of Lung Contusion as a Predictor of ARDS in the Multiple Trauma Patient

Lars M. Qvick, MD; Mark J. Anders, MD; Cathy Buyea, MS;  
Christopher E. Muttly, MD; Lawrence B. Bone, MD;  
State University of New York at Buffalo School of Medicine,  
Erie County Medical Center, Buffalo, New York, USA

**Purpose:** The etiology of adult respiratory distress syndrome (ARDS) has been difficult to assess as several publications report. The orthopaedic trauma literature suggests that a pulmonary contusion with a lung volume of  $\geq 20\%$  is associated with the development of ARDS. We analyzed data on 586 consecutive multiple trauma patients with lung contusions to determine any association with the development of ARDS.

**Methods:** A report of all multiple trauma patients with lung contusions presenting to our Level I Trauma center from January 2007 through May 2011 was requested after receiving university IRB approval. This report contained 586 patients. All patients were reviewed for the development of ARDS following the guidelines in the American European Consensus Conference on ARDS Definition ( $\text{PaO}_2/\text{FIO}_2$  ratio  $< 200$  with diffuse bilateral infiltrates and no evidence of congestive heart failure). 55 patients met the criteria for ARDS and a subsequent lung volume calculated following the methods of Strummwasser et al. A matched cohort (age  $\pm 3$  years, ISS  $\pm 7$ ) to those developing ARDS was randomly selected and lung contusion volumes were calculated. Continuous variables were compared with independent  $t$  tests, categorical with  $\chi^2$  or Fisher exact test. The odds of developing ARDS in the matched group were analyzed with conditional logistic regression.

**Results:** There was a significant difference between those who developed ARDS and those who did not in: systolic blood pressure (SBP), Glasgow coma score (GCS), Base Excess (BE), days on ventilator, ISS, AIS (Abbreviated Injury Scale), and total days in the hospital in the analysis of all 586 patients (table). Mortality was significantly increased in those patients who developed ARDS ( $P = 0.025$ ). Matched analysis consisted of 90 patients. Significant predictors for developing ARDS were GCS (odds ratio [OR] = 0.91; 95% confidence interval [CI] = 0.84, 0.99) and BE (OR = 0.55; 95% CI = 0.35, 0.87); volume of lung contusion was not significant ( $P = 0.36$ ). Volume of lung contusion as a categorical value of  $< 20\%$  and  $\geq 20\%$  was not a significant predictor of ARDS ( $P = 0.14$ ).

**Conclusion:** These data do not support the hypothesis that volume of lung contusion is a predictor of development of ARDS.

ARDS	Contusion Volume	Age	SBP	GCS	$\text{PaO}_2$	BE	Vent. Days	ISS	AIS	Total Days
Yes	18.7	46.6	130.9	8.52	127.1	-5.45	17.3	31.2	3.7	28.7
No	15.3	42.2	138.0	12.73	109.2	-3.41	6.4	22.6	3.0	8.6
$P$	0.275	0.18	0.09	0.001	0.27	0.001	0.001	0.001	0.01	0.001

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**The Psychological Consequences and Benefits of Traumatic Injury**

Jennifer Steel, PhD<sup>1</sup>; Dana J. Farrell, BS<sup>2</sup>; Peter Siska, MD<sup>2</sup>; Maranda N. Friday, MS<sup>1</sup>; Kendal A. Kingsley, MS<sup>1</sup>; Tiana L. Robinson, MS<sup>1</sup>; Hans-Christoph Pape, MD<sup>2</sup>; Ivan S. Tarkin, MD<sup>2</sup>;

<sup>1</sup>Center for Excellence in Behavioral Medicine, Department of Surgery and Psychiatry, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania, USA;

<sup>2</sup>Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

**Background/Purpose:** A plethora of research has been conducted on the psychological consequences of traumatic injury. However, limitations of prior studies, examining the prevalence of depression and posttraumatic stress disorder (PTSD), often fail to assess the consequences of prior traumatic events that may confound the prevalence of depression and PTSD. Furthermore, the timing of assessment in previous research is often months or years after the traumatic event. Finally, no study to our knowledge has explored the role of posttraumatic growth (PTG), which may facilitate recovery from the trauma. The aims of the study were to (1) assess the prevalence of depression and PTSD in patients who have experienced a traumatic injury immediately after the trauma to begin to understand the course of symptoms over time, (2) examine the association between previous traumatic events and current psychological symptoms, and (3) investigate the role of PTG in trauma patients.

**Methods:** 20 patients who had experienced a traumatic injury that included at least one long bone fracture were enrolled in the present study. Patients were enrolled at the time of their first outpatient visit after being discharged from the hospital and administered the Center for Epidemiological Studies–Depression scale, the Purdue Post-Traumatic Stress Disorder–Revised, and the Post Traumatic Growth Inventory. Descriptive statistics,  $\chi^2$  analyses, and analysis of variance were employed to test our aims.

**Results:** The majority of patients were male (74%) with a mean age of 45 years (SD = 13 years). The primary type of accident included motor vehicle accident (55%), falls (30%), suicide (10%), and gunshot wound (5%). 53% percent of the patients reported a prior trauma event. 47% of patients reported depressive and PTSD symptoms in the clinical range. 35% of patients reported clinical levels of both depression and PTSD. No gender differences were reported with regard to those who reported clinical levels of depression or PTSD. Symptoms of PTSD were not associated with prior traumas even when the patient reported that the event was traumatic at the time of the event or the interview. Trauma patients had lower levels of PTG when compared to the general population and people with chronic disease.

**Conclusions:** Preliminary results suggest that high rates of depression and PTSD, when compared to the general population, were observed early after the trauma. These psychological symptoms may interfere with rehabilitation and educational, occupational, and interpersonal functioning. The development of novel interventions, and early implementation of these interventions, is warranted. Providing psychological intervention early after the traumatic injury may prevent further consequences of traumatic injury (eg, nonadherence to rehabilitation and ongoing physical impairment, divorce, unemployment).



**The Impact of Major Operative Fractures in Blunt Abdominal Injury**

Nickolas J. Nahm, MD; John J. Como, MD; Timothy A. Moore, MD; Heather A. Vallier, MD; MetroHealth Medical Center, Cleveland, Ohio, USA

**Purpose:** Abdominal injury has been shown to be an independent risk factor for pulmonary complications in patients with extremity injuries. The combination of abdominal trauma with extremity injuries may result in massive hemorrhage and predispose the patient to systemic complications. We propose to characterize orthopaedic patients with severe abdominal trauma. We hypothesize that operative fractures of the thoracolumbar spine, pelvis, acetabulum, or femur increase systemic complications in patients with blunt abdominal injury.

**Methods:** All patients presenting to a Level I trauma center with abdominal injury between 2000 and 2006 were reviewed. Adult patients between the ages of 18 to 65 years with high-energy, blunt trauma resulting in severe abdominal injury (abdomen abbreviated injury scale [AIS]  $\geq 3$  and ISS  $\geq 18$ ) were included. Patients were divided into two comparison groups: the fracture group had operative fractures of the pelvis, acetabulum, thoracolumbar spine, and/or femur and the control group did not sustain these fractures of interest. Systemic complications were documented, including acute renal failure, deep venous thrombosis, pulmonary embolism, pneumonia, sepsis, acute respiratory distress syndrome (ARDS), multiple organ failure, and death. Unadjusted and multivariable logistic regression analyses were performed.

**Results:** The control group included 91 patients, and the fracture group included 106 patients with 136 fractures of interest. The most severe abdominal injury, defined by the abdominal organ with the highest AIS in each patient, more frequently involved the spleen in the control group (57% [52 of 91] vs 22% [23 of 106]) and the bladder in the fracture group (28% [30 of 106] vs 0% [0 of 91]) ( $P < 0.001$ ). In addition, the control group had more frequent embolization of the spleen (26% [24 of 91] vs 8% [8 of 106]) while the fracture group more often underwent damage control laparotomy (15% [16 of 106] vs 7% [6 of 91]) or primary repair of bladder (9% [10 of 106] vs 0% [0 of 91]) as the initial abdominal procedure ( $P < 0.001$ ). In the fracture group, most patients (65%, 36 of 57) received their initial abdominal intervention prior to their initial orthopaedic intervention. With unadjusted analysis, the fracture group had more complications (34% [36 of 106] vs 18% [16 of 91];  $P = 0.010$ ), including ARDS (8% [8 of 106] vs 1% [1 of 91];  $P = 0.040$ ), and sepsis (11% [12 of 106] vs 3% [3 of 91];  $P = 0.056$ ). Furthermore, the order in which abdominal and orthopaedic interventions were performed was not associated with development of complications. Logistic regression modeling demonstrates that the presence of fracture increases the odds of developing at least one complication approximately three times (odds ratio = 2.88,  $P = 0.006$ ), after controlling for presence of chest injury and injured abdominal organ.

**Conclusions:** Operative fractures of the thoracolumbar spine, pelvis, acetabulum, and femur increase the risk of developing systemic complications in patients with blunt abdominal injury. Blood loss associated with these injuries and their operative intervention may account for this finding. Further study is necessary to optimize treatment protocols for these high-risk patients.

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### **A Prospective Comparison of Two Approved Systems for Autologous Bone Marrow Concentration Demonstrated Nonequivalency in Progenitor Cell Number and Concentration**

*Vishal Hegde, BA<sup>1,2</sup>; Owolabi Shonuga, BS<sup>1,2</sup>; Joseph M. Lane, MD<sup>1</sup>; Scott J. Ellis, MD<sup>1</sup>; Austin T. Fragomen, MD<sup>1</sup>; Valery Kudryashov<sup>1</sup>;*

*<sup>1</sup>Hospital for Special Surgery, New York, New York, USA;*

*<sup>2</sup>Weill Cornell Medical College, New York, New York, USA*

**Purpose:** Both animal and human studies have demonstrated that the osteogenic capacity of bone marrow is affected by cell number and concentration. Currently, bone marrow aspiration (BMA) and concentration (BMAC) systems undergo US Food and Drug Administration (FDA) approval through the 510(k) clearance process to establish substantial equivalence. The purpose of this study was to evaluate the efficacy of two FDA-approved BMAC systems, the Harvest SmartPreP 2 BMAC and Biomet BioCUE systems, by comparing the number and concentration of osteoprogenitor cells achieved both before and after centrifugation, and the percentage of osteoprogenitor cells that are salvaged after centrifugation.

**Methods:** 20 patients (10 male, 10 female, mean age  $47 \pm 18$  years) undergoing a variety of procedures requiring bony or cartilaginous healing by 3 orthopaedic surgeons who had indicated the patients for concomitant autologous bone marrow grafting were consented. BMA was performed simultaneously from the iliac crests bilaterally. Each system was assigned a side at random. Samples for analysis were taken both immediately prior to and after centrifugation. The number of progenitor cells in each sample was estimated by counting the fibroblast colony-forming units (CFU-F). The yield was calculated by dividing the absolute number of CFU-F in the BMAC by the absolute number of CFU-F in the BMA. Significance was calculated using the nonparametric Mann-Whitney *U* test (statistical significance set at  $P = 0.05$ ).

**Results:** The Harvest system achieved a significantly greater number and concentration of progenitor cells both before and after centrifugation when compared with the Biomet system (see table). There was no difference in the percent yield of progenitor cells after centrifugation between the two systems ( $P = 0.48$ ).

**Table** Comparison of cellular composition of Harvest and Biomet system bone marrow aspirate and bone marrow concentrate

Fibroblast Colony-Forming Units (CFU-F)		Harvest (Mean ± SD)	Biomet (Mean ± SD)	P Value
BMA	Absolute Number of CFU-F	12,282 ± 19,475	2684 ± 2532	0.001
	Concentration (CFU-F/mL)	205 ± 324	54 ± 51	0.003
BMAC	Absolute Number of CFU-F	7,370 ± 13,842	806 ± 946	<0.001
	Concentration (CFU-F/mL)	1,053 ± 1,977	134 ± 158	<0.001
Yield (%)		57.22 ± 25.57	44.47 ± 36.97	0.480

**Conclusion:** The Harvest system demonstrated superior efficacy by achieving a significantly greater absolute number and concentration of progenitor cells both before and after centrifugation. As the number of progenitor cells in autologous bone marrow graft influences healing, the Harvest system should have a greater impact on healing potential. It is apparent that approval of devices through the 510(k) process may not guarantee comparable performance.

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### Distal Locking Using an Electromagnetic Field–Guided Computer-Based Real Time System for Orthopaedic Trauma Patients

Maxwell K. Langfitt, MD; Jason J. Halvorson, MD; Aaron T. Scott, MD; Beth P. Smith, PhD; Gregory B. Russell, MS; Riyaz H. Jinnah, MD; Anna N. Miller, MD; Eben A. Carroll, MD; Wake Forest Baptist Medical Center, Winston-Salem, North Carolina, USA

**Background/Purpose:** Intramedullary nails are the gold standard in treatment of lower extremity long bone fractures. Many surgeons use a freehand or “perfect circle” technique to place distal interlocking screws, which involves intraoperative fluoroscopy to guide drilling and interlocking screw placement. Potential pitfalls with this technique include increased operative time, radiation exposure, and the potential to “miss” the nail. Sureshot (Smith & Nephew) is a new electromagnetic field real time system (EFRTS), which provides surgeons with an alternative technique for distal interlock placement without radiation exposure. The purpose of this study was to compare the efficacy of distal locking using a freehand technique versus the EFRTS. We hypothesized that the utilization of the EFRTS would decrease operative times, decrease “misses,” and offer an effective alternative to traditional freehand techniques.

**Methods:** 48 patients aged 18 to 86 years were prospectively enrolled and randomized. This cohort included 24 tibia and 24 femur fractures amenable to antegrade intramedullary nailing. Each patient had two distal interlocking screws placed: one using the freehand method and one using the EFRTS. The order of screw placement was randomized. Data analysis compared the freehand method versus the EFRTS on procedural time and number of interlocking screw misses. Two specific time points were measured: time 1 (time to find perfect circles/time from “wand placement” to time of drilling initiation); and time 2 (initiation of drilling until completion of interlocking screw placement). Time comparisons were made between intervention with paired *t* tests and between junior (postgraduate year [PGY] 2, 3) and senior (PGY 4, 5) residents with Wilcoxon rank-sum tests for each intervention.

**Results:** The EFRTS proved faster at time 1 and time 2 ( $P < 0.0001$  and  $P < 0.0002$ , respectively). EFRTS was also significantly faster for total time ( $P < 0.0001$ ). This difference was larger for junior residents, although it did reach statistical significance for PGY-5 residents. Upper level residents were faster at the freehand technique compared to junior residents ( $P < 0.006$ ), but the two groups were similar in time taken for screw placement with the EFRTS ( $P = 0.27$ ). The number of misses was higher with freehand as opposed to EFRTS ( $P = 0.034$ ).

**Conclusion:** The gold standard treatment of lower extremity long bone fractures remains the intramedullary nail. However, distal interlocking screw placement can be difficult for those who do not perform intramedullary nailing on a consistent basis, resulting in increased operative time, radiation exposure, and interlocking screw misplacement. Studies have shown statistically significant differences in radiation exposure in experienced versus inexperienced surgeons performing the freehand distal interlock technique. Experiments using cadaveric tibia and femur specimens demonstrated that both the freehand and electromagnetic wand techniques were effective in locking, but the electromagnetic wand took less time, involved no radiation exposure, and resulted in fewer locking screw misses. Our data suggest that the EFRTS is faster and resulted in fewer screw misses. This trend was most pronounced

for junior residents but did still reach significance for senior residents. EFRTS may provide a reliable alternative to standard freehand interlocking screw placement and may reduce procedural time, radiation exposure, and inadvertent interlocking screw misses. Larger prospective trials are warranted.

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### Platelet-Rich Plasma in Delayed Unions

Daniel G. Monzon, MD<sup>1</sup>; Alberto Cid Casteulani, MD<sup>2</sup>; Kenneth Iserson, MD<sup>3</sup>;

Eliseo Firman, MD<sup>2</sup>; Santiago Svarzchtein, MD<sup>2</sup>; Sebastian Sasaki, MD<sup>2</sup>; Diego Roncolato, MD<sup>2</sup>;

<sup>1</sup>Hospital Italiano de Buenos Aires, Buenos Aires, Argentina;

<sup>2</sup>Centro Medico Integral Fitz Roy, Buenos Aires, Argentina;

<sup>3</sup>University of Arizona, Tucson, Arizona, USA

**Purpose:** New technologies for the enhancement of skeletal repair have led to the development of less invasive therapies combined with osteosynthesis procedures. We report our experience and results using platelet-rich plasma gel (PRPG) injection as an alternative method to open grafting techniques.

**Methods:** 69 occupationally active patients were treated from 2005 to 2009 at a single institution. Average age was 53.4 years (range, 26-72 years). Exclusion criteria were infected nonunion, pathologic fracture, previous external fixation, steroid therapy, hypertrophic nonunion, and platelet count <100,000 cells/mL. All cases presented long bones (25 femur, 11 humerus, 33 tibiae), delayed union (>8 months without radiographic consolidation), and located in the diaphyseal tract of the bone. The procedure was removal of preexisting hardware and intramedullary nails; bacterial samples were taken from the medullary canal. The intramedullary nail was inserted anterograde in femurs and tibiae and retrograde in the humerus. At the same time a platelet concentrate was obtained from 55 cm<sup>3</sup> of patients' blood with a centrifuge. 6 cm<sup>3</sup> of PRPG activated was injected at the nonunion site. After surgery all patients started rehabilitation with partial weight bearing at 4 weeks on tibia and femur, and 3 weeks on humeral procedures. The patients were examined clinically and radiographically at 45 days, and monthly up to consolidation or a year. Union was defined when callus formation is detected on both radiographic views on at least 3 of 4 cortices. If required, CT scan was performed.

**Results:** Surgery duration averaged 66 minutes (range, 40-140 min), optimal nail position and stability was achieved in all cases. No complications such as hematoma, neurovascular lesion, or delayed wound healing were detected when using injection of PRPG. On late post-operative evaluation, no infection was observed. Bone healing was achieved in 65 patients (94%) at final follow-up. The 4 remaining patients (2 tibiae, 1 femur, and 1 humerus) were reoperated and decortication, new reaming, and bone graft with PRPG was added. The average time for bone union was 14.3 weeks (range, 12-31). 5 CT scans were done, with 5 rotational malalignments, and 3 limb shortenings (with no patient discomfort) were detected. Nail removal was required after a year in 3 patients (2 tibiae and 1 humerus), due to pain at insertion site. On lower limb functional results, 49 of 55 patients (89%) return to previous activities, and 6 (11%) required a walking aid during long walk distances. In 2 patients with humeral nonunion treated, a limitation on abduction power and external rotation and diffuse pain was recorded. 10 patients (16%) were recategorized on their labor tasks, to a lower-demand job. 40 of 65 patients (61.5%) returned to recreational sports activities.

**Conclusion:** The combination of treatment with stable fixation and biological matrix give excellent results, with no major complications and with a shorter average healing time.

### **The Utility of the Free Anterolateral Thigh Flap for Reconstruction of Soft-Tissue Defects Associated With Extremity Fractures**

*Ariel Bowman, MS<sup>1</sup>; Jaimo Ahn, MD, PhD<sup>2</sup>; L. Scott Levin, MD<sup>2</sup>;*

*Samir Mehta, MD<sup>2</sup>; Stephen J. Kovach, MD<sup>3</sup>;*

*<sup>1</sup>Perleman School of Medicine at the University of Pennsylvania, Philadelphia, Pennsylvania, USA;*

*<sup>2</sup>Department of Orthopaedic Surgery, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania, USA;*

*<sup>3</sup>Division of Plastic Surgery, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania, USA*

**Background/Purpose:** Traumatic injuries to the extremities with associated soft-tissue loss represent a challenge to orthopaedic and plastic surgeons. Adequate fixation of the bony injury is doomed to failure without adequate soft-tissue coverage. Many injuries with associated large soft-tissue defects require free tissue transfer for adequate reconstruction. Additionally, many of these patients require multiple orthopaedic surgeries that necessitate a soft-tissue reconstruction that can facilitate re-elevation and access to the underlying bone. The anterolateral thigh (ALT) flap is a free fasciocutaneous perforator flap that is suited to revision and re-elevation with exposure of the underlying bone as opposed to muscle free flaps. The purpose of this study was to review the use of the ALT flap in microvascular reconstruction of traumatic extremity defects.

**Methods:** A retrospective chart review was conducted over a 4-year period (2007-2011) of all free tissue reconstructions of traumatic extremity injuries at an urban Level I trauma center. Inclusion criteria were patients receiving a free ALT flap as their soft-tissue reconstruction within 6 months of their initial orthopaedic extremity trauma. Clinical outcomes were examined, including flap viability after revision orthopaedic surgery.

**Results:** 64 patients underwent reconstruction with an ALT flap during the review period. 28 patients met inclusion and exclusion criteria. There were no partial or complete flap losses. One patient was taken back for a venous thrombosis that was repaired. Secondary orthopaedic revisions were required in 10 of 28 patients without associated soft-tissue complications.

**Conclusions:** The ALT flap is a durable fasciocutaneous flap that is ideal for soft-tissue reconstruction of traumatic defects of the extremities. It has minimal donor-site morbidity, can be harvested in the supine position, has a low complication profile, and can provide for coverage of large surface areas. Additionally, it is easy to re-elevate the flap for secondary revisions to the underlying bone. The ALT flap should be considered for soft-tissue reconstructions of the extremities, especially in those patients who will require secondary procedures.

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**•rhBMP-2 in the Treatment of Long Bone Nonunions Is No Advantage Over Autogenous Bone Graft Alone**

*Jordanna Forman, BS; Richelle C. Takemoto, MD; Kenneth A. Egol, MD; NYU Hospital for Joint Diseases, New York, New York, USA*

**Background/Purpose:** Bone graft has many biological properties that play a role in its adaptability. The bone morphogenetic proteins (BMPs) and other related growth factors play a crucial role in bone graft efficacy. However, no studies have compared the efficacy of autologous iliac crest bone graft and recombinant human BMP-2 (rhBMP-2) to autologous bone graft (ABG) alone. The objective of this study was to examine the clinical outcome of patients with long bone fracture nonunions treated with ABG and rhBMP-2 versus ABG alone.

**Methods:** 98 patients with 98 nonunions in long bone fractures were identified and retrospectively evaluated. 55 patients were treated with rhBMP-2 and ABG while 43 patients were treated with ABG alone. Medical records including clinical data referring to the initial injury, past surgical history, and time elapsed from the initial management to operative intervention was reviewed. Clinical and radiographic assessment was performed at 6 weeks, and 3, 6, 12, and 24 months. Time to healing, complications, and reoperations were recorded and compared between the two groups to determine if there was a difference between patients treated with rhBMP and ABG or ABG alone.

**Results:** Nonunion sites included clavicle, femur, tibia, forearm, humerus, and fibula and were classified as hypertrophic or atrophic. No significant differences existed between age, gender, mechanism of injury, or site of nonunion between the two groups. No incidence of donor-site morbidity was reported in patients who underwent autogenous bone grafting. The average time to union in the rhBMP-2 group was 6.5 months (range, 3-26 months) while the group treated with ABG alone had an average time to union of 5.3 months (range, 2-24 months). Patients who underwent rhBMP and ABG underwent a mean of 2.1 (range, 0-39) previous surgical interventions. 10.3% of this group required a reoperation after treatment with the allograft due to hardware failure and persistent nonunion and one patient (1.7%) failed to unite. A total of 8 patients (13.3%) were found to have positive bacterial intraoperative cultures. Patients who were treated with ABG alone underwent a mean of 1.6 past surgical interventions. Significantly more nonunions were classified as atrophic in this group compared to the group treated with rhBMP and ABG ( $P = 0.01$ ). 7.0% of patients required revision nonunion surgery after the bone graft. Positive cultures were discovered in 6 patients (13.9%). One subject (2.3%) failed to unite and underwent multiple revisions and ultimately required a below-the-knee amputation.

**Conclusion:** rhBMP-2 is a safe adjuvant to autologous iliac crest bone graft. However, rhBMP-2 did not provide a synergistic effect when used together with autologous bone graft. There is no statistically significant difference in time to union when rhBMP-2 and ABG are used together to treat nonunion of long bones compared to ABG alone. Given the high cost of this product, use of rhBMP-2 should be reconsidered as an aid to surgically treat nonuniting fractures.

See pages 97 - 144 for financial disclosure information.



**Does Adding a Nail Make a Difference?**

*Daniel S. Chan, MD<sup>1</sup>; Gerald E. Alexander, III, MD<sup>2</sup>, Ian R. Smithson, MD<sup>2</sup>;*

*Roy Sanders, MD<sup>1</sup>; H. Claude Sagi, MD<sup>1</sup>;*

*<sup>1</sup>Orthopaedic Trauma Service, Florida Orthopaedic Institute, Tampa, Florida, USA;*

*<sup>2</sup>University of South Florida, Tampa, Florida, USA*

**Background/Purpose:** In the case of intramedullary osteomyelitis, intramedullary reaming is an effective means of débridement. Several reports have described the additional use of antibiotic-impregnated cement nails, but this is not considered standard treatment. To the best of our knowledge, no study has directly compared standard reaming débridement alone to reaming plus the addition of the antibiotic-loaded cement nail. The purpose of this study is to directly compare reaming with placement of an intramedullary antibiotic-impregnated cement nail versus intramedullary reaming alone.

**Methods:** A retrospective chart review was performed at a single Level I trauma center. Our database contains 542 patients treated from 1989 through 2010 with a diagnosis of osteomyelitis. 50 of the most recent patients with intramedullary osteomyelitis that underwent reaming and antibiotic-impregnated cement nail placement were compared with the first 150 patients treated with reaming alone by retrospective chart review. Inclusion criteria consisted of skeletal maturity, intramedullary sepsis, treatment with débridement via reaming, hardware removal at time of operation, minimum of 4 weeks organism-specific antibiotics, and minimum 1-year follow-up. 59 patients were available for review. Of those patients, 47 patients were treated with reaming alone (RA), and 12 were treated with reaming with the addition of an antibiotic-impregnated cement nail (RAN). All patients had a minimum of 4 weeks antibiotics per the recommendations of our institution's Infectious Disease Department. Data collected included chronicity of the infection, Cierny classification, infecting organism, antibiotic regimen, total number of procedures, and osteomyelitis recurrence, as well as any complications.

**Results:** There was no difference between the groups with regards to Cierny classification. Median follow-up of RA patients was 11.19 years (range, 5-18 years), and the median follow-up of RAN patients was 1.5 years (range, 1-2.25 years). Patients who underwent RA had a recurrence rate of 34% (16 of 47 patients), and those who underwent RAN had a recurrence rate of only 8% (1 of 12 patients),  $P = 0.15$ . There were a total of 28 combined recurrences of osteomyelitis observed in the 16 RA patients, with the average instances of recurrence of osteomyelitis per patient of 1.75 (range, 1-4 recurrences per patient) and a median time of recurrence at 0.51 years (range, 0.09-7.24 years) postoperatively. The single RAN patient with recurrence of osteomyelitis had a single recurrence at 1.14 years postoperatively. The RAN arm of our review is underpowered ( $\beta = 0.29$ ), and we would need at least 45 patients to achieve 80% power and determine statistical significance. One RA patient with osteomyelitis refractory to eradication went on to an amputation, and none of the RAN patients had complications.

**Conclusion:** Reaming with the addition of antibiotic-impregnated cement nails resulted in a markedly lower rate of osteomyelitis recurrence when compared to reaming alone,

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with an overall relative decrease of 76%. In addition, the overall number of recurrences of osteomyelitis per patient was also decreased. The time until recurrence was similar between groups, lowering the possibility of length time bias. Complications with RAN were decreased when compared with RA. A clear trend exists toward improved outcomes with the use of antibiotic nails in the treatment of osteomyelitis. Further investigation is warranted with larger sample sizes.

**Locked 90° Blade Plates in Metaphyseal Proximal Humerus Nonunion**

*Christian Allende, MD; Martin Mangupli, MD;  
Hospital Nacional de Clínicas, Cordoba, Argentina*

**Background/Purpose:** A need for revision surgery and a range of complications higher than expected has been reported with the use of blade plates and locked plates in proximal humerus nonunions. In order to decrease these complications, and to increase the stability in complex metaphyseal nonunions of the proximal humerus, we used locked 90° blade plates in 39 cases. We sought to prospectively evaluate the results achieved with the use of 90° blade plates with locked divergent screws in nonunions of the proximal humeral metaphysis.

**Methods:** 39 metaphyseal nonunions of the proximal third of the humerus, stabilized with a blade plate with locked screws between 2004 and 2011, were prospectively evaluated. 17 nonunions were oligotrophic and 22 atrophic. Patient age averaged 69 years (range, 41-86). Time from trauma to definitive surgery averaged 21 months. 27 patients had had previous surgical treatments. MIPPO (minimally invasive percutaneous plate osteosynthesis) was used in three cases. Autogenous cancellous iliac-crest bone graft was used in 25 cases and morcellized cryopreserved bone allograft in six cases.

**Results:** Follow-up averaged 31 months (range, 12-63); union was achieved in 38 cases after an average of 5 months. Disabilities of the Arm, Shoulder and Hand (DASH) score averaged 21 points (range, 0-61). Constant score averaged 76 points (range, 51-96). One patient, with seven previous operations, and in which morcellized bone graft was used, developed osteonecrosis and nonunion, but did not accept further treatment. No other patient required additional procedures, nor was there any infection or hardware protrusion or failure.

**Conclusions:** Surgical treatment of nonunions of the proximal metaphysis of the humerus remains a challenge. 90° locked blade plates combine the advantages of blade plates with those of locked plates, increasing medial metaphyseal support. The results after the use of locked 90° blade plates are encouraging, especially considering the complexity of the lesions treated.

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### If Treatment of Nonunions With ICBG Works, Adding BMP-2 Must Work Better— Right or Wrong?

*William M. Ricci, MD; Philipp N. Streubel, MD;*

*Christopher M. McAndrew, MD; Michael J. Gardner, MD;*

*Washington University School of Medicine, Saint Louis, Missouri, USA*

**Purpose:** Autologous iliac crest bone graft (ICBG) is considered the gold standard for grafting of nonunions. Bone morphogenetic protein (BMP)-2 has yielded similar healing rates in the treatment of some nonunions. The purpose of the present study was to assess if the combination of the two is better than ICBG alone.

**Methods:** 76 patients with nonunions treated with either ICBG alone or ICBG + BMP-2 were studied. Patients (53% male, mean age 52 years [range, 18-85]) were followed for at least 1 year or until nonunion healing. Average follow-up was 12 months. 51 patients (67%) were treated with ICBG alone and 25 (33%) with ICBG + BMP-2. An osteoconductive adjuvant was used in 25 cases when the volume of ICBG was insufficient.

**Results:** No significant differences ( $P > 0.05$ ) in demographics, nonunion type (atrophic vs either oligotrophic or hypertrophic), or type of surgery (open reduction and internal fixation vs intramedullary nail) were found between the two groups. Osteoconductive adjuvants were used more often in the ICBG + BMP-2 cases ( $n = 14, 56%$ ) than the ICBG alone cases ( $n = 11, 22%$ ) ( $P < 0.01$ ). There was neither a statistical nor a clinically relevant difference in the nonunion healing rates after the index nonunion repair between the groups ( $P = 0.60$ ). 44 (86%) healed with ICBG alone and 21 (84%) healed with ICBG + BMP-2. There was 1 infection in each group ( $P = 0.21$ ). Among 51 nonunions that did not receive osteoconductive augmentation, there was no significant difference in healing rates between groups (ICBG alone [90%] vs ICBG + BMP-2 [82%]) ( $P = 0.39$ ). Similarly, of the 25 nonunions that did receive osteoconductive augmentation, healing rates between the two groups were similar: 77% in the ICBG alone group and 86% in the ICBG + BMP-2 group ( $P = 0.38$ ).

**Conclusions:** Nonunion repair with ICBG alone was highly successful (86%). The addition of BMP-2 offered no improvement in healing rates. Although BMP-2 has been shown to be effective in treating nonunions in the absence of ICBG, it appears to offer little benefit when ICBG is utilized.

**Treatment of Open Supracondylar Femur Fractures With Segmental Bone Loss***William M. Ricci, MD; Philip N. Streubel, MD; Christopher M. McAndrew, MD;**Michael J. Gardner, MD;**Washington University School of Medicine, Saint Louis, Missouri, USA*

**Purpose:** High-energy open supracondylar femur fractures often result in segmental bone loss after initial débridement procedures. The outcomes of any treatment method for these injuries have been infrequently reported. The purpose of this study was to evaluate a treatment protocol of acute débridement, locked plating, and planned staged autologous bone grafting.

**Methods:** 103 consecutive patients treated for a supracondylar femur fracture between 2001 and 2008 were retrospectively identified from hospital and orthopaedic department databases. Of these, 11 (9%) with open fractures had associated segmental bone loss after débridement. Average age was 50 years (range, 31-78), and eight patients were male. All were treated with a protocol of immediate débridement, locked plating within 14 days of injury, and a plan for staged bone grafting. Patient demographics, mechanism, fracture characteristics, complications, and additional procedures were analyzed.

**Results:** The average defect was 7.6 cm (range, 2-16 cm). Two patients healed without requiring a graft while nine had a planned staged autologous iliac crest bone graft placed at an average of 95 days after initial injury. Four of the nine healed after the index bone graft procedure. Five of the nine required additional bone grafting procedures to achieve union. Three patients (27%) developed deep infection. All patients eventually healed and were without evidence of residual infection at an average follow-up of 18 months.

**Conclusions:** Open supracondylar femur fractures with large areas of segmental bone loss are extremely challenging injuries. A protocol involving débridement, primary locked plating, with a plan for staged autologous iliac crest bone grafting yielded eventual union in all patients. However, this group of severely injured patients treated in this manner should be counseled that multiple grafting procedures and interval treatment for infectious complications are commonly necessary.

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### A New Classification for Complex Lumbosacral Injuries

Ronald A. Lehman, Jr., MD<sup>1</sup>; Daniel G. Kang, MD<sup>1</sup>; Carlo Bellabarba, MD<sup>2</sup>;

<sup>1</sup>Walter Reed National Military Medical Center, Bethesda, Maryland, USA;

<sup>2</sup>University of Washington Medical Center, Seattle, Washington, USA

**Background/Purpose:** The optimal classification for complex lumbosacral injuries, in particular high-energy sacral fractures and lumbosacral dissociation injuries, remains controversial. Currently used classification systems for complex lumbosacral injuries are largely descriptive, lacking validity, reproducibility, treatment considerations, and prognostic information. We set out to develop a comprehensive, yet practical, classification system for complex lumbosacral injuries that assists in clinical decision-making.

**Methods:** We developed a new classification system and injury severity scoring system for complex lumbosacral injuries derived through extensive literature review, expert opinion, and our clinical experience treating combat casualties over the past 10 years. We have seen an increased incidence of complex sacral fractures and lumbosacral dissociation injuries after combat-related high-energy blast trauma, motor vehicle collisions, and aircraft crashes. A pilot validation study was performed with 4 spine surgeons familiar with lumbosacral injuries and 10 case scenarios. Inter- and intraobserver reliability was analyzed using intra-class correlation coefficients (ICCs).

**Results:** A new classification system was devised based on three injury characteristics: (1) fracture morphology (flexion compression, axial compression, translation/rotation, blast/shear), (2) posterior ligamentous complex (PLC) integrity (intact, indeterminate, disrupted), and (3) neurologic status (intact, paresthesias only, lower extremity motor deficit, progressive neurologic deficit). A composite injury severity score (CISS) was calculated by summing a weighted score from each category with increasing score associated with increased injury severity. Treatment recommendation is then based on CISS less than 3 (nonoperative), greater than 3 (operative), equal to 3 (either). We found good to excellent ICC for interobserver reliability (injury morphology = 0.757; PLC integrity = 0.720; neurologic status = 0.990; CISS = 0.934), and good to excellent ICC for intraobserver reliability (range 0.712 to 1 for all CISS components).

**Conclusion:** We propose the Lumbo-Sacral Injury Classification System (LSICS), which provides a comprehensive and practical approach for evaluating injury severity and guiding clinical decision-making. A multicenter study with application of LSICS to a large number of cases is necessary to determine the reliability and validity of this new classification system.

#### LSICS Interrater Reliability

Variable	Round 1	Round 2	Average
CISS	0.930	0.989	0.960
Morphology	0.692	0.823	0.758
Neurology	1.000	0.972	0.986
PLC	0.879	0.694	0.787

See pages 97 - 144 for financial disclosure information.

### LSICS Intrarater Reliability

Variable	Evaluator #1	Evaluator #2	Evaluator #3
CISS	0.979	0.911	1.000
Morphology	1.000	0.712	0.959
Neurology	1.000	0.957	1.000
PLC	0.773	0.800	0.901

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**Posterior Stabilization of Thoracolumbar Spine Fractures:  
Retrospective Analysis of Percutaneous Versus Open Management**

Miguel Pishnamaz, MD; Stavros Oikonomidis, MD; Richard M. Sellei, MD;  
Philipp Lichte, MD; Klemens Horst, MD; **Hans-Christoph Pape, MD**; Philipp Kobbe, MD, PhD;  
Department of Orthopaedic and Trauma Surgery, University Hospital RWTH, Aachen, Germany

**Background/Purpose:** Posterior instrumentation is the treatment of choice for unstable fractures of the thoracolumbar spine. Minimally invasive percutaneous procedures are becoming increasingly popular. However, percutaneous systems have limited fracture reduction possibilities as compared to the conventional open management. The aim of this retrospective study was to compare the percutaneous versus the open management.

**Method:** We undertook a retrospective evaluation of operatively treated unstable A- and B- fractures of the thoracolumbar spine (T12-L2) in 2011 in our hospital. Patients without complete data documentation and <18 years of age were excluded. Investigated parameters were operation time, time of intraoperative fluoroscopy, postoperative infections, incidence of required revisions, need for postoperative blood transfusion, and length of hospital stay. Furthermore, screw diameter, screw length, and position as well as postoperative reposition results have been evaluated. The statistical analysis was performed using SPSS 18.

**Results:** 66 patients (21 minimal invasive, 45 open) aged 18 to 80 years with A- or B- fractures of the thoracolumbar spine were included. The groups were comparable regarding age, gender, fracture location, and fracture type. There were no significant differences in terms of operative time (open 118 min vs minimally invasive 122 min), postoperative infections, or revision surgeries. The length of hospitalization was also not significantly different (7.51 days open vs 7.71 days minimally invasive). Patients of the minimally invasive surgery group required significantly fewer postoperative blood products (0 patients minimally invasive vs 9 patients open;  $P < 0.05$ ). The time of intraoperative fluoroscopy was significantly higher in patients with percutaneous minimal invasive treatment (144.8 sec vs 102.5 sec;  $P < 0.05$ ). The extent of fracture reduction was significantly higher in patients managed with open surgery ( $7.82^\circ$  vs  $4.47^\circ$ ;  $P < 0.05$ ). Additionally, the chosen screws were significantly longer in patients of the open surgical treatment than in the minimally invasive-operated (56.38 mm vs 45.83 mm;  $P < 0.05$ ). However, there was no significant difference in the screw diameter (open 6.17 mm vs 6.27 mm).

**Conclusion:** The percutaneous posterior stabilization reduces the postoperative requirement for red blood cells, but is associated with increased fluoroscopy time. Percutaneous fracture management results in less fracture reduction and shorter pedicle screws, which may increase the risk for implant failure.



### **The Reliability of the Thoracolumbar Injury Classification and Severity Score Among Orthopaedic Surgeons at Different Levels of Training**

*Adam J. Bevevino, MD; Ronald A. Lehman, MD; Daniel G. Kang, MD; John P. Cody, MD; Robert W. Tracey, MD; Donald Hope, MD; Walter Reed National Military Medical Center, Bethesda, Maryland, USA*

**Background/Purpose:** Despite the increased use of the Thoracolumbar Injury Classification and Severity Score (TLICS), it has not yet gained universal acceptance. In the Emergency Department, the least experienced orthopaedic surgeon (intern/junior resident) often performs the initial evaluation of a patient with thoracolumbar spine trauma. They must then relay reliable information to staff spine surgeons that is imperative for efficient care and initial treatment decision-making. Our objective was to examine the reliability of TLICS among orthopaedic physicians from intern to staff level surgeons.

**Methods:** Ten cases of thoracolumbar spine fractures were reviewed and scored using TLICS by eight evaluators: intern (n = 2), junior level orthopaedic resident (n = 3), senior level resident (n = 2), and spine surgeon (n = 1). Each participant evaluated the same cases on three different occasions. Statistical analysis with intraclass correlation coefficients (ICCs) was conducted assessing the inter- and intraobserver reliability of the TLICS classification.

**Results:** Interobserver reliability yielded moderate to excellent agreement between evaluators in all three rounds of testing. Neurologic injury produced the highest ICCs, ranging from 0.820 to 0.902. Fracture morphology demonstrated the lowest interobserver ICCs, with moderate agreement of 0.449 and 0.423. Intraobserver ICCs improved with increasing levels of training. The intern evaluators recorded the lowest intraobserver ICCs, while the staff surgeon scored the highest. Staff surgeon ICCs all ranked above 0.800 for excellent intraobserver agreement. Fracture morphology produced the lowest intraobserver ICCs, ranging from 0.586 to 0.683. The total severity score yielded the highest intraobserver ICCs of 0.768 to 0.920 for interns through senior residents.

**Conclusions:** The use of the TLICS demonstrated moderate to excellent intra- and interobserver reliability among all training levels. Senior residents and staff demonstrated improved ICCs in higher training levels; however, interns and junior residents were able to reliably classify spinal trauma injuries. This suggests that the TLICS scheme is a reliable way to successfully communicate thoracolumbar injury information.

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### Reliability of the Subaxial Cervical Spine Injury Classification System for Orthopaedic Surgeons at Different Training Levels

Daniel G. Kang<sup>1</sup>; Ronald A. Lehman Jr<sup>1</sup>; Adam J. Bevevino<sup>1</sup>; John P. Cody<sup>1</sup>; Alpesh A. Patel<sup>2</sup>; Scott C. Wagner<sup>1</sup>; Donald N. Hope<sup>1</sup>;

<sup>1</sup>Walter Reed National Military Medical Center, Bethesda, Maryland, USA;

<sup>2</sup>Loyola University Health System, Chicago, Illinois, USA

**Background/Purpose:** The Subaxial Cervical Spine Injury Classification System (SLICS) was developed to address the shortcomings of other classifications. In the emergency department, the least experienced orthopaedic surgeon (intern/junior resident) often performs the initial evaluation of a patient with thoracolumbar spine trauma. They must then relay reliable information to staff spine surgeons that is imperative for efficient care and initial treatment decision-making. The purpose of our study was to evaluate the reliability of the SLICS and severity score among orthopaedic physicians at different levels of training.

**Methods:** Ten cases of subaxial cervical spine fractures, including plain radiographs, CT, and MRI, were reviewed and scored using SLICS by eight evaluators: intern (n = 2), junior level resident (n = 3), senior level resident (n = 2), fellowship-trained staff spine surgeon (n = 1). Statistical analysis with intraclass correlation coefficients (ICCs) was conducted assessing the inter- and intraobserver reliability of the SLICS classification.

**Results:** Interobserver reliability yielded moderate to excellent agreement between evaluators in all three rounds of testing. Neurologic status and total severity score produced the highest ICCs, ranging from 0.830 to 0.925. Discoligamentous complex (DLC) integrity demonstrated the lowest interobserver ICC scores with moderate agreement of 0.449 and 0.423. Intraobserver ICCs improved with increasing levels of training. The intern evaluators recorded the lowest intraobserver ICCs, while the staff surgeon scored the highest. Staff surgeon ICCs all ranked above 0.800 for excellent intraobserver agreement. DLC integrity produced the lowest intraobserver ICCs, ranging 0.0.397 to 0.707. The total severity score yielded the highest intraobserver ICCs of 0.768 to 0.920 for interns through senior residents.

**Conclusion:** The use of the SLICS demonstrated excellent intra- and interobserver reliability among orthopaedic surgeons of different training levels, ranging from orthopaedic intern to staff spine surgeon, and good reliability for use in treatment recommendation. However, more experienced orthopaedic surgeons, particularly senior resident and staff level orthopaedic surgeons, had better intraobserver reliability with the use of the SLICS and in evaluating DLC integrity.

<b>SLIC Interobserver Reliability Values</b>	
<i>Variable</i>	<i>Total</i>
<b>Severity Score</b>	0.865
<b>Morphology</b>	0.730
<b>Neurologic Status</b>	0.914
<b>DLC Integrity</b>	0.518

<b>SLIC Intraobserver Reliability Values</b>				
<i>Variable</i>	<i>Interns</i>	<i>Juniors</i>	<i>Seniors</i>	<i>Staff</i>
<b>Severity Score</b>	0.814	0.861	0.922	0.941
<b>Fracture Morphology</b>	0.601	0.782	0.774	0.827
<b>Neurologic Status</b>	0.867	0.906	0.975	0.966
<b>DLC Integrity</b>	0.468	0.388	0.706	0.848

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**The Perfused, Pulseless Supracondylar Humerus Fracture: Intermediate Follow-up of Vascular Status and Function**

*Steven L. Frick, MD; Christopher Bray, MD; Brian Scannell, MD; J. Benjamin Jackson, III, MD; Timothy S. Roush, MD, MPH; Brian K. Brighton, MD, MPH; Carolinas Medical Center, Charlotte, North Carolina, USA*

**Purpose:** This study provides intermediate vascular status follow-up of a cohort of perfused, pulseless supracondylar humerus fractures (PPSCHFs) in children managed with closed reduction, pinning, and careful observation.

**Methods:** Pediatric patients sustaining a PPSCHF from 2007 to 2010 and with at least 6 months of clinical follow-up were identified by chart reviews; phone contact was attempted and patients were invited to return for evaluation. The primary outcome assessed was vascular status evaluated by palpation of pulse, wrist:brachial index (WBI), and arterial patency on duplex ultrasound. Secondary outcomes were functional outcomes based on the Pediatric Outcomes Data Collection Instrument (PODCI), arm circumference, arm length, range of motion, neurologic examination, muscle endurance testing, grip strength testing, and questioning for cold intolerance.

**Results:** 22 patients sustained a PPSCHF during the study period, and 9 patients have returned for clinical examination. All had Gartland type III fractures, and were managed with closed reduction and percutaneous pinning (CRPP) and admission to observe postoperative pain, perfusion, and neurologic status. Mean age at injury was 8 years old (range, 3-14). Mean time from injury to follow-up was 2 years (range, 6 months–4 years). Four patients had a neurologic deficit at the time of injury (median nerve, anterior interosseous nerve). Two patients had a palpable pulse return immediately postoperatively. No patient developed compartment syndrome or Volkmann's ischemic contracture. All had a palpable radial pulse at last follow-up, and all nerve palsies resolved. Six had patent brachial arteries on duplex ultrasound. Three had occlusion with large collateral vessels. All six patients with a patent and one patient with an occluded brachial artery had normal WBI. Two patients with occluded brachial artery had abnormal WBI (73%, 71%). No differences were observed in average arm circumference, arm length, range of motion, muscle endurance, or grip strength compared to the uninjured side. One patient reported cold intolerance during ice hockey. The PODCI questionnaire demonstrated higher functioning of all domains in seven of nine patients compared to the general population. Two patients (one with occluded artery, one with patent artery) scored lower than the general population on two of six scales.

**Conclusion:** At average 2-year follow-up, children with PPSCHFs managed with CRPP demonstrate palpable distal pulses, normal growth, and overall excellent functional outcomes, although three of nine had an occluded brachial artery. We do not advocate for routine vascular exploration in patients with a PPSCHF.

### A Radiographic Study of the Ossification of the Posterior Wall of the Acetabulum: Implications for the Evaluation of Posterior Wall Fractures in Children

*Peter D. Fabricant, MD; Brandon P. Hirsch, MD; Ian Holmes, BS; Milton T. M. Little, MD; Marschall B. Berkes, MD; Eric A. Bogner, MD; David L. Helfet, MD; Dean G. Lorich, MD; Daniel W. Green, MD;*

*Hospital for Special Surgery, New York, New York, USA*

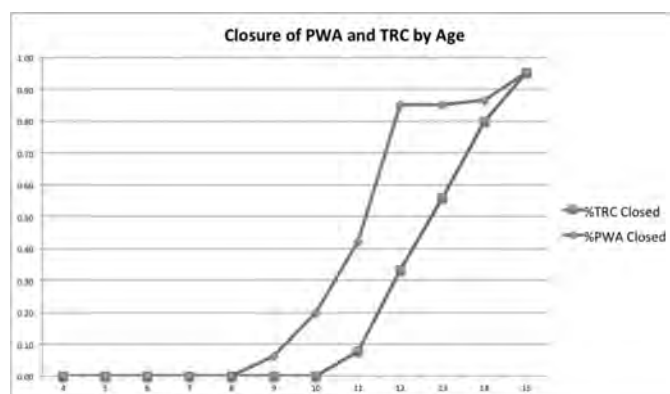
**Purpose:** Plain radiographs and CT scans can misjudge the size of posterior acetabular wall fractures after traumatic dislocation in children due to the partially calcified nature of pediatric bone. During this time, MRI is suggested to fully characterize fracture fragments. However, the ossification pattern of the posterior wall of the acetabulum (PWA) is not well described and it is therefore unclear at what age conventional imaging may be used. The purpose of this study is to characterize the radiographic ossification pattern of the PWA, and determine when conventional imaging (radiographs, CT scans) may be used to characterize traumatic posterior wall lesions.

**Methods:** 180 MRI and corresponding plain radiographic studies performed in patients 4 to 15 years old were evaluated. Studies were excluded if patients carried diagnoses that would affect physeal growth. All MRI sequences (including physeal-specific sequences) and corresponding AP pelvis radiographs were evaluated by an attending radiologist to characterize ossification of the PWA and triradiate cartilage (TRC).

**Results:** Ossification of the PWA followed a specific and predictable pattern. At age 7, the central ossification center of the PWA begins to ossify, followed by a discrete posterior rim area of calcification noted on MRI and plain radiography peaking at age 12, followed by fusion of all posterior wall centers to the pelvis. Complete posterior fusion took place by age 13 in a vast majority of subjects, followed by closure of the TRC in all subjects (figure). On average, males' PWA fused 1 to 1.5 years after females'.

**Conclusion:** The PWA closes in a predictable manner prior to closure of the TRC. Radiographic and CT evaluation of posterior wall lesions are not advised until after closure of the TRC as prior to this time the PWA is not fully ossified. Rather, MRI is the preferred

cross-sectional imaging modality in these patients. Finally, this study defines a previously undescribed ossification center along the posterior rim of the acetabulum ("posterior rim sign"), which is seen just prior to final PWA fusion and should not be confused with posterior wall injury.



**Figure.** Closure of PWA and TRC by age.

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**Pediatric Supracondylar Humerus Fractures: A Technique to Aid in Closed Reduction**

Mary A. Herzog, MD<sup>1</sup>; Shelley M. Oliver, MD<sup>1</sup>; James R. Ringler, MD<sup>1,2</sup>;

Debra L. Sietsema, PhD<sup>2</sup>; Clifford B. Jones, MD<sup>1,2</sup>;

<sup>1</sup>Grand Rapids Medical Education Partners Orthopaedic Surgery Residency Program, Grand Rapids, Michigan, USA;

<sup>2</sup>Orthopaedic Associates of Michigan, Michigan State University, Grand Rapids, Michigan, USA

**Background/Purpose:** Pediatric supracondylar humerus fractures (PSCHFs) are the most common fracture of the pediatric elbow. Meticulous reduction and anatomic alignment of the fracture are essential to restore normal elbow function and to prevent future complications from malreduction and resultant abnormal joint kinematics. Anatomic reduction of displaced PSCHFs may not be possible via closed manipulation in unstable fracture patterns, necessitating formal open reduction. Open reduction has been associated with increased risks of elbow stiffness, myositis ossificans, scarring, and iatrogenic neurovascular injury.

**Methods:** From March 2002 through December 2010, 145 displaced (Gartland type II or III) PSCHFs were treated operatively at a Level I trauma center by a single fellowship-trained orthopaedic trauma surgeon and retrospectively identified. In Group 1 (March 2002 through September 2007), fractures failing successful reduction via closed manipulation underwent formal open reduction. In Group 2 (October 2007 through December 2010), fractures irreducible via simple closed reduction underwent a new technique involving percutaneous Schanz pin placement in the humeral shaft to assist in fracture reduction. This involved using a 2.4-mm terminally threaded Schanz pin placed in the posterior distal humeral diaphysis. The use of this pin as a joystick assisted in reduction of anterior/posterior translation as well as the reduction of varus/valgus malalignment, but was instrumental in derotation of the humeral shaft, which is often the impediment to a successful closed reduction. Following fracture stabilization, the Schanz pin was removed. Demographic data, fracture type, operative technique, complications, and radiographic reduction were analyzed for all fractures. Operative time for all type III fractures in Group 2 was also recorded.

**Results:** Group 1 had 91 fractures (33 type II and 58 type III), and Group 2 had 54 fractures (15 type II and 39 type III). There were two open fractures, one in each group. Significantly less type III fractures in Group 2 compared to Group 1 required open reduction ( $P = 0.025$ ), with 11 of 58 (17.2%) type III fractures in Group 1 and 1 of 39 (2.6%) type III fractures in Group 2. 10 of the 39 (25.6%) type III fractures in Group 2 utilized the Schanz pin technique, and all of these achieved anatomic reduction. No fracture treated with the Schanz pin reduction technique required open reduction. The average operative time for Group 1 fractures treated with open reduction was 32.7 minutes, whereas the average operative time for Group 2 fractures treated with the Schanz pin technique was 22.0 minutes ( $t = 2.417$ , significance = 0.029). There were two superficial pin infections, both in Group 1. No significant difference was found between Groups 1 and 2 for fracture reduction (as determined on AP and lateral radiographs) or complications. No radial nerve palsies occurred with the use of the Schanz pin technique.

**Conclusion:** The use of a posteriorly placed Schanz pin aids in timely anatomic reduction and decreases the need for open treatment of displaced PSCHFs, without compromising final reduction or complication rates.

See pages 97 - 144 for financial disclosure information.

### Association of Pelvic Ring Injuries in Pediatric and Adolescent Patients With Injury Severity Score and Need for Transfusion

Laura W. Lewallen, MD; S. Andrew Sems, MD; Amy L. McIntosh, MD;  
Mayo Clinic, Rochester, Minnesota, USA

**Purpose:** The purpose of this study is to determine whether pelvic fracture pattern (as defined by the OTA classification system) is associated with transfusion requirements or concomitant injuries (ISS) in pediatric and adolescent patients.

**Methods:** This was a single institution, retrospective review of pelvic fractures in pediatric and adolescent patients between January 1970 and December 2000. Fractures were classified by the OTA fracture classification system. Associated injuries were recorded, and ISS was assigned retrospectively using the 2005 AIS (Abbreviated Injury Scale) scores. Transfusion requirements during the hospital stay were also noted.

**Results:** 90 patients met inclusion criteria for this study. There was a nearly equal gender distribution (males 51.1%, females 48.9%), with an average age of 10.9 years (range, 2-16). The most common mechanism of injury was motor vehicle accident (41.1%), followed by pedestrian/bike vs auto accident (25.6%). 21 patients (23.9%) received a blood transfusion, of 6.9 units on average. One patient died as a result of injuries sustained. There were 27 A-type (30.0%), 51 B-type (56.7%), and 12 C-type (13.3%) injuries. The most common fracture type subgroup was 61 B2.1 with 29 patients (32.2%). The average ISS was 12.77. The mean ISS scores by fracture subclassification were: 8.1 for 61 A, 12.7 for 61 B, and 23.6 for 61 C ( $P < 0.0001$ ). When comparing across groups, we also found significant differences: A-C ( $P < 0.0001$ ), B-C ( $P < 0.0001$ ), and A-B ( $P = 0.0165$ ). Blood transfusions were administered in 23.9% of patients. Decreasing stability of pelvic ring fractures was associated with increasing transfusion requirements. 14.8% of A-type, 18.4% of the B-type, and 66.7% of the C-type injuries required transfusion ( $P = 0.0009$ ). There was no significant association with the number of units transfused, however ( $P = 0.9614$ ). Age was not statistically associated with fracture type ( $P = 0.6072$  for 61 A/B/C), ISS ( $P = 0.1199$ ), or the need for blood transfusion ( $P = 0.2643$ ).

**Conclusion:** Decreased pelvic ring fracture stability was associated with an increased need for blood transfusion, although not the number of units. In addition, pelvic ring fracture stability may be a marker of associated injuries (ISS).

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**Management and Outcomes of Adolescent Supracondylar Humerus Fractures**

*Bryan J. Loeffler, MD<sup>1</sup>; Steven L. Frick, MD<sup>2</sup>; Brian K. Brighton, MD<sup>2</sup>; R. Glenn Gaston, MD<sup>3</sup>; Virginia F. Casey, MD<sup>3</sup>; Melissa Earles, MD<sup>4</sup>; Kyle J. Jeray, MD<sup>4</sup>; David Bissing<sup>5</sup>; Lisa K. Cannada, MD<sup>5</sup>; Robert A. Hymes, MD<sup>6</sup>;*

<sup>1</sup>Thomas Jefferson University, Philadelphia, Pennsylvania, USA;

<sup>2</sup>Carolinas Medical Center, Charlotte, North Carolina, USA;

<sup>3</sup>OrthoCarolina, Charlotte, North Carolina, USA;

<sup>4</sup>Greenville Hospital System, Greenville, South Carolina, USA;

<sup>5</sup>Saint Louis University, Saint Louis, Missouri, USA;

<sup>6</sup>Inova Fairfax Hospital, Falls Church, Virginia, USA

**Purpose:** Supracondylar fractures of the distal humerus in adolescents are rare injuries, and there are little data in the literature to support the ideal treatment for these injuries. The purpose of this study is to determine whether treatment of these patients as pediatric patients (with percutaneous fixation and a period of immobilization) or as adults (with open reduction and internal fixation [ORIF] and early motion) results in superior outcomes.

**Methods:** A multicenter, retrospective cohort study of clinical and radiographic outcomes was performed on 71 patients aged 10 to 17 years with a supracondylar humerus fracture. Patients were treated at four Level I trauma centers from 2005 to 2011, and the mean follow-up was 9 months (range, 2-52 months). The type of approach and surgical fixation were performed at the surgeon's discretion.

**Results:** There were 41 OTA type A2 and A3 fractures and 30 OTA Type C fractures. Nine (12.7%) fractures were open injuries. 35 patients (49%) were treated with ORIF, while 36 patients (51%) were treated with closed or mini-open reduction and percutaneous fixation (CRPP). 34 of the patients (48%) were treated by pediatric fellowship-trained orthopaedic surgeons. All fractures healed, and elbow pain was minimal or nonexistent at the latest follow-up for all patients. There were no differences in the radiographic alignments (Baumann's angle and alignment on lateral radiograph) achieved when comparing the ORIF and CRPP groups, and no corrective osteotomies for malunions were performed in either group. The total arc of motion achieved was similar in the ORIF and CRPP groups (overall mean 115°), and a functional arc of motion was achieved by an average of approximately 3 months postoperatively. Persistent ulnar nerve symptoms were observed in 6% of patients in the CRPP group and 11% in the ORIF group postoperatively ( $P = 0.04$ ). A secondary procedure was performed on 34% of the patients who underwent ORIF compared to 8% of the patients in the CRPP group ( $P < 0.001$ ). Formal physical therapy was prescribed for 25% of patients in the CRPP group versus 82% of patients in the ORIF group ( $P < 0.001$ ).

**Conclusions:** Excellent short- to intermediate-term clinical and radiographic results may be achieved with either pediatric or adult-type management of these fractures. ORIF was associated with significantly higher rates of ulnar nerve dysfunction, secondary procedures, and utilization of formalized physical therapy. Experienced surgeons in Level I trauma centers chose the treatment option for each patient, and thus selection bias is likely present.



### **Surgical Hip Dislocation Is Safe for the Treatment of Incomplete Reduction Following Traumatic Hip Instability in Adolescents**

*David A. Podeszwa, MD; Adriana DelaRocha, MS; Daniel J. Sucato, MD;*  
*Department of Orthopaedic Surgery, University of Texas Southwestern and*  
*Texas Scottish Rite Hospital for Children, Dallas, Texas, USA*

**Purpose:** The use of the surgical hip dislocation (SHD) approach has not been previously reported for the treatment of adolescent hip trauma. The purpose of our study was to review our early clinical and radiographic results of this approach to treat intra-articular pathology resulting from traumatic instability in adolescents. We hypothesized that the SHD approach is safe and effective for treatment of entrapped labrum or osteocartilaginous (OC) fragments following traumatic hip instability in adolescents.

**Methods:** This was a single institution clinical and radiographic review of consecutive patients undergoing the SHD approach for treatment of a CT/MRI confirmed incomplete reduction following traumatic hip instability. Intra-articular soft-tissue or OC fragments were confirmed by CT/MRI preoperatively. Particular attention is paid to the description of the intraoperative findings, immediate postoperative complications, the development of osteonecrosis (ON), and the acetabular morphology.

**Results:** Ten skeletally immature male patients with a mean age of 11.9 years (range, 9.3-14.2) and mean body mass index (BMI) of 18.2 (range, 15.4-24.8) presented following posterior traumatic hip instability (dislocation requiring reduction = 7; subluxation/spontaneous reduction = 3). Mechanism of injury included football (6), motor vehicle accident (3), and roller skating (1). Postreduction radiograph/CT confirmed an incongruent joint reduction secondary to entrapped soft-tissue or OC fragments. All underwent SHD with the following intraoperative findings: labral tear (9), femoral cartilage injury (5), acetabular rim fracture (4), acetabular cartilage delamination (9), loose body (2), femoral head OC fracture (1). Associated procedures included: labral repair (6), loose body removal (4), OC fracture repair (3). Immediately postoperatively, one patient developed a transient peroneal nerve palsy. At a mean of 23 months (range, 12-48) postoperatively, there is no evidence of ON. Radiographically, the mean lateral center edge angle of the effected hip was 21° (range, 9°-38°) with 6 hips <20°. The mean acetabular index was 9° (range, -2° to 23°) with 4 hips >10°. The mean acetabular version (based on CT or MRI) was 9° (range, 8°-16°) with 8 hips <15°. At last follow-up the mean self-reported functional score (modified Harris hip score) was 94.4 (range, 84.7-100).

**Conclusions:** Early results suggest SHD is a safe approach to treat an incomplete reduction following posterior hip instability in the adolescent population. The SHD is effective for identification and treatment of acute intra-articular pathology, some of which may not be identified on the preoperative CT/MRI images. Acetabular dysplasia and/or relative retroversion may be a risk factor for posterior hip instability in this population.

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### Incidence, Bacteriology, and Risk Factors of Infection in Smooth Wire Fixation in Pediatric Orthopaedic Surgery

Abtin Foroohar, MD; Richard Tosti, MD; Jennifer Brey, MD;

Martin Herman, MD; Peter Pizzutillo, MD;

St. Christopher's Hospital for Children, Philadelphia, Pennsylvania, USA

**Purpose:** Few studies have addressed the incidence of major infections following smooth pin fixation in the pediatric orthopaedic population. We present data in order to characterize the incidence, bacteriology, and risk factors of these infections. Additionally, we have provided a treatment algorithm for clinicians, which was developed from a series of infection cases.

**Methods:** A retrospective chart analysis of 409 pediatric patients was performed on all cases in which smooth wires were implanted during a 7-year period. Risk factors such as age, location of pin, buried versus percutaneous pin, elective versus traumatic surgery, and time to diagnosis were analyzed. All cases in which hospitalization was required were additionally screened for culture data, clinical course, and outcome.

**Results:** The overall infection rate was 1.22%. The final diagnosis was cellulitis in 2 cases and osteomyelitis in 3 cases. Toxic shock syndrome presented in one case of cellulitis. All infection cases were from percutaneous wires placed for trauma; however, no statistical difference was detected between traumatic and elective cases or buried and percutaneous pins. Staphylococcal species were the most common pathogens. In the two cases of cellulitis, the pins were left in place through the treatment of the infection, and these fractures healed with sequelae.

**Conclusion:** The overall incidence of smooth wire infection in pediatric orthopaedics is low and most commonly caused by Staphylococcus species. If the fracture is not yet united and the infection is superficial, the pins can be maintained during the treatment of the infection.

**Table** Factors in the development of major infections following smooth wire placement

Variable	Major Infection	No Infection	Odds Ratio	95% Confidence Interval	P Value
Traumatic	5	304	∞	(0.423-∞)	0.201
Elective	0	100			
Age <8	1	158	2.72	(0.403-18.25)	0.355
Age >8	4	246			
Percutaneous pin	5	384	∞	(0.073-∞)	0.589
Buried pin	0	22			
Upper extremity	4	272	1.73	(0.256-11.6)	0.622
Lower extremity	1	132			

**Triplane/Tillaux Fractures: How Much Gap or Step is Acceptable?**

*Imran K. Choudhry, MD<sup>1</sup>; Alvin H. Crawford, MD<sup>2</sup>; Charles T. Mehlman, DO, MPH<sup>2</sup>;*

*Eric J. Wall, MD<sup>2</sup>; Emily A. Eisman, MS<sup>2</sup>; Lindsay M. Wilson, BA<sup>2</sup>;*

*<sup>1</sup>University of Cincinnati Department of Orthopaedics, Cincinnati, Ohio, USA;*

*<sup>2</sup>Cincinnati Children's Hospital, Cincinnati, Ohio, USA*

**Purpose:** The aim of this study was to examine the midterm functional outcomes of triplane and Tillaux fractures of the distal tibia as they relate to residual articular gap and step-off.

**Methods:** A retrospective review of all triplane and Tillaux fractures treated at a single institution between 2000 and 2009 was conducted. 27 patients met the criterion of 2-year minimum follow-up. All included patients completed the Foot and Ankle Outcome Score (FAOS) and Marx Activity Scale via a mailed survey.

**Results:** 12 (44%) had step-off or gap post reduction/fixation that ranged between 1.0 and 2.6 mm. Patients reported high levels of function: 5 patients reported perfect ratings on the symptoms scale (20%), 13 patients on the pain scale (52%), 16 patients on the activities of daily living scale (64%), 14 patients on the sports and recreation scale (56%), and 10 patients on the quality of life (QOL) scale (40%). Postoperative gap and step-off were not correlated with any of the functional scales (Table 1, Spearman's two-tailed correlation,  $P > 0.05$ ). When grouped, the 15 patients without a gap or step-off post reduction/fixation did not differ on any of the functional scales from the 12 patients with a gap and/or step-off post reduction/fixation (Table 2, Mann-Whitney test,  $P > 0.05$ ).

**Conclusion:** Patients with residual post reduction/fixation step-off or gap at the articular surface of triplane and Tillaux fractures in the 1.0- to 2.4-mm range are not at risk for poor functional outcomes compared to those with no radiographically measurable gap/step-off. Our study validates the concept that gap or step-off of <3 mm provides excellent mid- to long-term patient-reported functional results.

Table 1		Postoperative Gap		Postoperative Step-Off	
		Correlation ( $r$ )	$P$ Value	Correlation ( $r$ )	$P$ Value
<b>FAOS</b>					
	Symptoms	-0.05	0.82	-0.11	0.58
	Pain	0.10	0.62	0.27	0.17
	Activities of daily living	-0.12	0.56	0.06	0.78
	Sports & recreation	0.11	0.57	0.26	0.20
	QOL	0.10	0.63	0.32	0.11
<b>Marx Scale</b>		0.04	0.83	-0.10	0.61

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Table 2	No Gap or Step-Off (N=15)	Gap and/or Step-Off (N=12)	Mann-Whitney Test
	Median (Interquartile Range)	Median ( Interquartile Range)	<i>U</i> ( <i>P</i> Value)
<b>FAOS</b>			
Symptoms	89.3 (85.7-96.4)	85.7 (82.1-95.5)	80.5 (0.64)
Pain	97.2 (88.9-100)	100 (91-100)	77.5 (0.52)
Activities of daily living	100 (92.6-100)	99.3 (96-100)	81.0 (0.62)
Sports & recreation	95 (85-100)	100 (81.3-100)	76.5 (0.48)
QOL	87.5 (68.8-100)	96.9 (75-100)	73.0 (0.39)
<b>Marx Scale</b>	9 (5-16)	9 (1.3-15.5)	81.5 (0.68)

**Tibial Nail Distal Positioning: A Radiographic Study**

*Travis E. Marion, MD; Steven R. Papp, MD; Wade T. Gofton, MD, MEd; Allan Liew, MD; University of Ottawa, Ottawa, Ontario, Canada*

**Background/Purpose:** Intramedullary fixation is the treatment of choice for diaphyseal tibia fractures. The importance of the proper insertion point is well established. Intramedullary fixation of distal tibial fractures relies upon the placement of the guidewire distally to achieve and maintain an acceptable reduction once the intramedullary nail has been inserted. Inappropriate distal positioning of the guidewire may contribute to malalignment when the nail is inserted, leading to malunion, ankle joint dysfunction, and early arthritic changes. The ideal distal position of the guidewire in the distal tibia has yet to be well defined.

**Methods:** 50 intact tibial radiographs were selected and evaluated. The center of the medullary canal at the level of the isthmus was established and extended inferiorly through the ankle joint on AP and lateral radiographs. Transverse lines of reference on the AP and lateral views were established. The position in which the isthmus line intersected these reference lines was measured and expressed as a percentage from medial to lateral on the AP view and anterior to posterior on the lateral view. The tibial radiographs were manually templated with sized tibial nails. The position in which the center of the implant template intersected the previously established reference lines was measured and once again expressed as a percentage.

**Results:****Nontemplated**

AP radiograph	Reference Line	Percent From Medial Cortex
	Maximal metaphyseal width	59.8 ± 4.1%
	Tibial articular width	63.5 ± 7.6%
	Talar width	60.3 ± 7.6%
Lateral radiograph	Maximal metaphyseal width	55.6 ± 5.1%
	Tibial articular width	60.7 ± 9.0%

**Templated**

AP radiograph	Reference Line	Percent From Medial Cortex
	Maximal metaphyseal width	60.1 ± 3.7%
	Tibial articular width	66.2 ± 6.1%
	Talar width	61.7 ± 7.6%
Lateral radiograph	Maximal metaphyseal width	55.7 ± 4.4%
	Tibial articular width	58.5 ± 8.4%

**Conclusions:** The ideal placement of the guidewire in the distal tibia for intramedullary fixation is not well defined. Traditional teaching calls for placement of the guidewire end

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point in the “center” of the ankle joint or distal tibia. Our findings demonstrate that the ideal end point for an intramedullary nail is lateral and central to the center of the maximum metaphyseal width reference line on AP and lateral view respectively. In treating distal third tibial fractures, one cannot rely on the isthmus to guide the intramedullary nail. Furthermore, positioning of the nail in the “center” on AP may shift the axial position of the talus and contribute to a malreduction, especially in the setting of distal comminution. This study supports further investigations to determine the effect of distal tibial nail malposition and its clinical significance.

### **Tibia-Based Referencing for Standard Proximal Tibial Radiographs During Intramedullary Nailing**

*Jesse E. Bible, MD; Ankeet A. Choxi, BE; Sravan Dhulipala, BS; Jason M. Evans, MD; Hassan R. Mir, MD;*

*Vanderbilt Orthopaedic Institute, Nashville, Tennessee, USA*

**Background/Purpose:** The anatomic safe zone for entry portal creation has been described in order to minimize intra-articular damage during intramedullary nailing of the tibia using standard AP and lateral (Lat) radiographs. However, there is limited information to define standard AP and Lat proximal tibial radiographs. A recent study showed that the nail entry point varies significantly with tibial rotation, and suggested that an AP radiograph with the fibular head bisected by the tibia correlated with an ideal entry point. Such a reference point can be unreliable due to normal or traumatic proximal tibiofibular joint variations. Additionally, the traditional Lat image referenced from the femoral condyles may be inaccurate due to normal or pathologic variations in knee alignment. The purpose of this study was to define new radiographic imaging landmarks on the proximal tibia for “standard” AP and Lat radiographs, and to compare intra-articular damage from nail entry portal creation with previous radiographic techniques.

**Methods:** 20 cadaveric knees (10 matched pairs) were used for this study. In Group 1 (10 knees), previously described fluoroscopic techniques were used, with bisection of fibular head considered the AP image, and femoral condyle overlap the Lat image. In Group 2 (10 knees), the “twin peaks” AP view, showing the sharpest profile of the tibial spines perpendicular to the tibial plateau was used as the AP image. The “flat plateau” Lat image was obtained by aligning the femoral condyles and then applying a varus adjustment to the image, perpendicular with overlap of the medial and lateral tibial plateaus. Medial peritendinous approaches were performed via a 3-cm skin incision and a guide pin was placed in the anatomic safe zone using the two fluoroscopic guidance techniques. A 12.5-mm entry reamer was used to open the medullary canal. All soft tissues were carefully removed, and damage to intra-articular structures was recorded.

**Results:** A priori analysis showed good to excellent intra- and interobserver reliability with the new radiographic technique used for Group 2 (intercorrelation coefficient 0.61-0.90). The “twin peaks” AP radiograph was externally rotated  $2.7 \pm 2.1^\circ$  compared to the standard radiograph using the fibular head bisection line. The “flat plateau” Lat radiograph involved directing the fluoroscopic beam  $1.6 \pm 2.9^\circ$  caudal (varus) compared to perfectly aligned femoral condyles. The average portal position relative to intra-articular structures, and the incidence of damage to intra-articular structures, did not significantly differ between Group 1 and Group 2 ( $P > 0.05$ ).

**Conclusions:** Radiographic referencing based on tibial anatomy was shown to have excellent intraobserver and interobserver reliability. The “twin peaks” AP view and the “flat plateau” Lat view can safely be used for tibial nail entry portal creation in the anatomic safe zone. Tibia-based radiographic referencing can be useful for intramedullary nailing cases in which local knee or proximal tibiofibular joint anatomy is significantly altered.

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## Identification of Optimal Control Compartments for Near-Infrared Spectroscopy Assessment of Lower Extremity Compartmental Perfusion

Keith Jackson, MD<sup>2</sup>; Ashley L. Cole, MPH<sup>1</sup>; Benjamin K. Potter, MD<sup>3</sup>; Tracy L. Kinsey, MSPH; Michael S. Shuler, MD; Emily K. Smith, MPH; Brett A. Freedman, MD

<sup>1</sup>University of Georgia, Athens, Georgia, USA;

<sup>2</sup>Cincinnati Children's Hospital, Cincinnati, Ohio, USA

<sup>3</sup>Department of Orthopaedics and Rehabilitation, Walter Reed National Military Medical Center, Bethesda, Maryland, USA

**Purpose:** The authors sought to examine within-subject, within-compartment variability of near-infrared spectroscopy (NIRS) measurement of tissue oxygenation, and investigate optimal control compartments for lower extremity monitoring, among uninjured volunteer subjects.

**Methods:** NIRS leads were applied over each of the 4 compartments of the lower extremities, as well as the volar and dorsal forearm, and deltoid in healthy volunteers between the ages of 18 and 65. Tissue oxygenation measures were recorded every 30 seconds for 1 hour ("Test 1"), using the INVOS Cerebral Oximeter (Somanetics). After an interval of at least 24 hours, all subjects returned for repeat monitoring ("Test 2"). Within-patient NIRS values over the 1-hour monitoring period were characterized using summary statistics. For bivariate comparisons, a single representative value ("summary NIRS value") was generated based on the average of a 5-minute monitoring period; once NIRS sensors of all compartments were attached and consistently recording values, a 5-minute stabilization period was discarded, and the following 5-minute period was selected and averaged. Pearson correlation coefficients and Spearman correlation coefficients were used to describe the relationship between NIRS values of the lower and upper extremity, as well as NIRS relationship with colorimeter values. Intraclass correlation coefficient (ICC) was used to evaluate the reliability of NIRS values between Test 1 and Test 2.

**Results:** Among 44 participants who completed testing, moderate within-patient, within-compartment variability was observed over the monitoring period (average interquartile range, 2.6 to 3.5 percentage points). However, summary NIRS values of analogous compartments of contralateral legs were highly correlated (Pearson correlations: anterior (A)  $r = 0.90$ , lateral (L)  $r = 0.81$ , superficial posterior (S)  $r = 0.78$ , deep posterior (D)  $r = 0.76$ ;  $P < 0.0001$  for all compartments). Of the 3 compartments tested in the upper extremity, the volar forearm was most highly correlated with compartments of the lower extremity (Pearson correlations:  $r = 0.71, 0.65, 0.65$ , and  $0.65$  for the anterior, lateral, superficial, and deep posterior compartments, respectively). Additionally, NIRS values demonstrated excellent reliability across the two days of monitoring (A: ICC = 0.80, L: ICC = 0.73, S: ICC = 0.81, D: ICC = 0.70).

**Conclusion:** NIRS represents a promising technological advance in the diagnosis of and monitoring for acute compartment syndrome. The results of this study suggest that continuous NIRS monitoring yields moderate variability within compartments over time, but analogous contralateral compartment NIRS values were extremely well-correlated in bivariate comparisons. Additionally, the authors observed that NIRS values of analogous compartments of the contralateral leg tended to closely mirror short-term changes of NIRS over time.

See pages 97 - 144 for financial disclosure information.



**Effect of Tibial Nonunion on Health-Related Quality of Life**

Mark R. Brinker, MD<sup>1</sup>; Bryan D. Hanus<sup>1</sup>; Milan K. Sen, MD<sup>2</sup>; Daniel P. O'Connor, PhD<sup>2</sup>;

<sup>1</sup>Department of Orthopaedic Surgery, University of Texas Medical School at Houston, Houston, Texas, USA;

<sup>2</sup>Department of Health and Human Performance, University of Houston, Houston, Texas, USA

**Purpose:** Tibial nonunion is disabling, but to our knowledge no quantitative evaluation of the effect on health-related quality of life (HRQOL) has been reported.

**Methods:** There were 260 consecutive patients with tibial nonunion (88 women, age  $46.3 \pm 15.6$  years; 172 men, age  $48.7 \pm 15.2$  years) who were referred to the one of us (M.R.B.) at our tertiary care center over a 10-year period (making this a single-surgeon series). The most frequently affected segment of the tibia was the distal third (44%), and 17% of all cases were infected on presentation.

**Results:** The 12-Item Short Form Health Survey (SF-12) Physical Component Scale scores averaged  $27.4 \pm 6.7$  and showed an extremely large and disabling effect on physical health. The Mental Component Scale averaged  $42.4 \pm 7.0$  and indicated a substantial detrimental effect on mental health. The impact on physical health was comparable to reported effects of end-stage hip arthrosis and was significantly worse ( $P < 0.005$ ) than congestive heart failure. The American Academy of Orthopaedic Surgeons Lower Limb Core Scale scores averaged  $51.9 \pm 19.3$  and were also consistent with high levels of physical disability attributable to the lower limb. Brief Pain Inventory Intensity averaged  $4.8 \pm 2.5$  and Interference averaged  $6.9 \pm 2.2$ , suggesting that pain was a substantial contributor to disability. Responses to the Time Trade-Off questionnaire indicated that patients were willing to trade an average of 36% of their remaining years of life to regain their health, which was equivalent to 12 years of life in these patients. The presence of infection did not significantly affect any of the HRQOL measures ( $P > 0.05$ ).

**Conclusion:** Tibial nonunion is an extremely disabling chronic medical condition that negatively affects both physical and mental health and quality of life. To the best of our knowledge, this is the first study of its kind reporting on a large consecutive series.

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### **Faster Surgery, Faster Union, But Less Stable Fixation in 50 Tibial Fractures Treated With the Fixion Expandable Intramedullary Nail Compared With a Matched Series of Interlocked Nails**

*Toby W. Briant-Evans, FRCS; Jonathan L. Hobby, FRCS; Geoff J. Stranks, FRCSEd;*

*Nigel D. Rossiter, FRCSEd;*

*Basingstoke and North Hampshire Hospital, Basingstoke, Hampshire, United Kingdom*

**Purpose:** The Fixion expandable nailing system provides an intramedullary fracture fixation solution without the need for locking screws. Proponents of this system have demonstrated shorter surgery times with rapid fracture healing, but several centers have reported suboptimal results with loss of fixation. In this largest comparative series to be reported to date with this device, we aimed to assess these claims with a prospective matched cohort study.

**Methods:** We compared outcomes between 50 consecutive diaphyseal tibial fractures treated with a Fixion device at our institution to an age, sex, and fracture configuration-matched series of 57 fractures at a neighboring hospital treated with a conventional interlocked intramedullary nail. Minimum follow-up time was 2 years.

**Results:** Operating time was significantly reduced in the Fixion group (mean 61 minutes; range, 20-99) compared with the interlocked group (88 minutes; range, 52-93) ( $P < 0.00001$ ). The union rate was no different between the Fixion group (93.9%) and the interlocked group (96.5%) ( $P = 0.527$ ). Time to clinical and radiological union was significantly faster in the Fixion group (median 85 days; range, 42-243) compared with the interlocked group (119; range, 70-362) ( $P < 0.0001$ ). The overall reoperation rate was lower in the Fixion series (24.5% vs 38.6%,  $P = 0.121$ ), although the majority of reoperations in the interlocked group were more minor, being for screw removal. Three Fixion nails were revised for fixation failure and two manipulations were required for rotational deformities after falls; all of these patients were noncompliant with postoperative instructions. There were no failures of fixation in the interlocked group. Three fractures were noted to propagate during inflation of Fixion nails.

**Conclusion:** The Fixion nail is faster to implant and allows more physiologic loading of the fracture, with a faster union time. However, these advantages are offset by a reduction in construct stability. Our results have demonstrated a learning curve with a reduction in complications as our indications have been narrowed, avoiding osteoporotic, multifragmentary, unstable fractures and noncompliant patients.

## Clamp-Assisted Intramedullary Nailing of Closed Spiral (OTA 42-A1 and B1) Tibia Fractures: A Comparative Study

Cory A. Collinge, MD<sup>1</sup>; Michael J. Beltran, MD<sup>2</sup>; Henry A. Dollahite, BS<sup>1</sup>; Florian G. Huber, MD<sup>3</sup>;

<sup>1</sup>Harris Methodist Hospital, Fort Worth, Texas, USA;

<sup>2</sup>San Antonio Military Residency, San Antonio, Texas, USA;

<sup>3</sup>Peninsula Orthopedic Associates, Salisbury, Maryland, USA

**Purpose:** The purpose of this study is to assess the results of percutaneous clamp-assisted reduction and nailing of simple spiral and oblique closed tibial shaft fractures compared with a those of similar patients nailed after manual fracture reduction held by the surgical team.

**Methods:** This is a retrospective comparative cohort study, involving a consecutive series of patients with a simple spiral and oblique closed tibial shaft fracture (OTA 42 A1 and B1). Compared were (1) those treated with tibial nailing without clamp-aided reduction (2000 to August 2005) and (2) those nailed with percutaneous clamp-assisted reduction (August 2005 to 2010). Standard reamed intramedullary nailing was performed in all cases. In the earlier cohort, fracture reduction during nailing was achieved and held manually (MRN) by the surgical team. The reduction method during tibial nailing of simple closed fractures was modified in mid2005 to the clamp-assisted nailing (CAN) technique using a pointed reduction clamp with wide excursion applied through percutaneous stab incisions. The main outcome measure was clinical and radiographic healing and alignment.

**Results:** There were 33 patients with 33 fractures in the MRN group and 32 patients with 33 fractures in the CAN group. There were scant differences in demographics and injury pattern between the two groups. Acceptable postoperative alignment was restored in 32 of 33 (97%) cases in the CAN group, while 26 of 33 (82%) cases were inadequately reduced in the MRN group ( $P < 0.05$ ). A widened residual fracture gap  $>3$  mm was seen in 14 of 33 (42%) patients in the MRN group, compared to 5 of 33 (15%) in the CAN group. There were statistical trends for malreduction in the sagittal plane ( $2.1^\circ$  vs  $1.2^\circ$ ,  $P = 0.07$ ) and increased fracture gap (2.2 mm vs 1.2 mm) in the MRN group compared to the CAN group. The mean time to healing was 22.4 weeks (range, 2.5-13 weeks) in the CAN group and 16.8 weeks (range, 1.5-7.8 weeks) in the MRN group ( $P = 0.053$ ). There were no wound problems seen in either group. There was one infection, seen in the CAN group, which appeared related to the distal locking screws and not the fracture site. One patient in the CAN group had ongoing numbness on the dorsum of the foot at latest follow-up (5 months).

**Conclusions:** This study demonstrates that percutaneous clamp-assisted reduction and nailing of simple spiral and oblique closed tibial shaft fractures is an effective technique that allows for early union with reproducible alignment and few clamp-related complications.

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### Increased Nonunion Rate and Delayed Union of Distal Tibia Fractures Treated With Intramedullary Nails and Angle Stable Interlocking Screws

Kevin M. Kuhn, MD<sup>1</sup>; Jason W. Stoneback, MD<sup>2</sup>; John A. Boudreau, MD<sup>2</sup>; J. Tracy Watson, MD<sup>2</sup>;

<sup>1</sup>Naval Medical Center San Diego, San Diego, California, USA;

<sup>2</sup>Saint Louis University Hospital, Saint Louis, Missouri, USA

**Background/Purpose:** Fractures of the distal tibia remain challenging injuries to treat. Intramedullary nailing of these fractures has been shown to produce high union rates, provide biomechanically stable fixation, and minimize surgical dissection. Nailing has produced favorable results for both extra-articular and simple articular fractures. Recent technological advances include the introduction of angle stable interlocking screws (ASIS) to create a fixed angle interface between the nail and metaphyseal bone of the distal tibia, thereby increasing the biomechanical characteristics of fixation as has been shown in other types of fractures. No clinical data or patient series is currently available evaluating clinical outcomes in patients treated with this technology. We hypothesized a higher union rate would be observed in distal tibia fractures treated with ASIS due to improved biomechanical properties.

**Methods:** A retrospective, single center review of 22 consecutive patients with distal tibia fractures treated with ASIS was performed. All patients had distal tibia fractures, with or without simple intra-articular extension, treated with intramedullary nailing with any number of ASIS placed in the distal segment. 16 patients had sufficient follow-up to meet inclusion criteria and were included in the study. Clinical records were reviewed with attention to demographic information, comorbidities, associated injuries, operative details, radiographic outcomes, complications, and need for secondary procedures. Primary outcomes were malunion (MU), nonunion (NU), time to union, and secondary procedures. Primary outcomes were compared to a historical control group from existing pertinent literature that used traditional interlocking screws.

**Results:** Of the 16 patients who met inclusion criteria, there were 6 open fractures. Nine fractures were classified as OTA type A, three as OTA type B, and four OTA type C fractures. The average time until union (in those patients not requiring secondary procedures) was 30 weeks (range, 11-56 weeks) and was longer than pooled controls (16.2-23.5 weeks). There were 8 NUs (50%) in those patients with adequate follow-up with 100% of these being atrophic. Pooled controls in the literature report union in 146 of 163 patients with a 10% NU rate. There was a statistical trend toward NU with more severe OTA fracture type ( $P = 0.061$ ). There were no deep infections or ASIS failures in the study group. There were no MUs. One fracture was malaligned after the index procedure and went on to a transtibial amputation for nonunion. The study group required a total of six secondary procedures. Of the fractures that healed primarily, most healed with little or no callus formation.

**Conclusions:** While ASIS technology has proved to be promising in biomechanical testing and showed improved healing in animal models, the results of our small clinical study group indicate a disproportionately high NU rate and prolonged union time compared to results of similar fractures treated with intramedullary nailing utilizing standard interlocking screws. These findings may be due to a construct that is too stiff, thereby inhibiting the

progression of secondary callus formation, yet not rigid enough to allow for primary bone healing. Although this is a small retrospective study, based on our data we have stopped using these implants and recommend cautious use of ASIS technology in this fracture pattern until higher-quality data is available to the contrary.

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**Tibial Nailing in the Setting of a Traumatic Knee Arthrotomy**

Jennifer M. Bauer, MD; Jesse E. Bible, MD; **Hassan R. Mir, MD**;  
Vanderbilt Orthopaedic Institute, Nashville, Tennessee, USA

**Purpose:** Intramedullary nailing of tibia fractures in the setting of a traumatic knee arthrotomy (TKA) frequently raises concern over adding a possible source of contamination to the fracture site with the introduction of the nail through a contaminated knee. However, this concern has never been investigated clinically. The purpose of this study was to analyze the rate of postoperative infection and nonunion following tibia nailing in the setting of a TKA.

**Methods:** A retrospective review of all adult traumatic tibia fractures treated with intramedullary nailing (N = 1378) at a single Level I academic center over a 10-year period found 21 tibial nails performed in the setting of a traumatic arthrotomy. Excluding patients with ballistic arthrotomies or follow-up <6 months, we reviewed the outcome of 14 tibial nails through TKAs with respect to postoperative infection and nonunion. We defined infection as cases treated with surgical débridement and irrigation at the knee or fracture site, and nonunion as those requiring surgical revision. The traumatic arthrotomy group was also compared to a 4:1 matched control group of 56 patients with tibial nails without TKA. We matched controls for age, injury (closed/open; if open, Gustilo type), diabetes, and smoking.

**Results:** There were no postoperative infections in the tibial nail with TKA group versus four (7.1%) in the control group ( $P = 0.577$ ). One nonunion (7.1%) was noted in the tibial nail with TKA group versus four (7.1%) in the control group ( $P = 1.000$ ). There were no significant differences ( $P = 0.795-1.000$ ) between the TKA and control groups for diabetes, smoking, body mass index, or ISS.

**Conclusion:** This is the first study to report outcomes of tibial nailing through a traumatic knee arthrotomy (TKA) with comparison to a matched control group, with no difference found in union rates or infection. Furthermore, no postoperative infections were identified in any of the patients treated with tibial nails placed in the setting of a TKA. This study documents the relative safety associated with tibial nailing in the setting of a concurrent TKA with appropriate surgical débridement and no contamination.

**Orthopaedic Infection Reduces Chances of Returning to Duty**

*Matthew A. Napierala, MD; Jessica C. Rivera, MD; Clinton K. Murray, MD; Travis C. Burns, MD; Joseph C. Wenke, PhD; Joseph R. Hsu, MD; Skeletal Trauma Research Consortium (STReC); San Antonio Military Medical Center, Fort Sam Houston, Texas, USA*

**Background/Purpose:** Infection is a potentially devastating complication following severe lower extremity trauma. The current literature indicates that infectious complications after severe lower extremity trauma correlate with poorer outcomes in the civilian population; however, their effect on combat casualties is less clear. The purpose of this study is to characterize the impact of infectious complications on overall disability and return to duty for wounded soldiers who sustained significant lower extremity trauma. We hypothesize that orthopaedic infectious complications will have a negative impact on holistic patient outcome as measured by return to duty (RTD) and disability rating.

**Methods:** We reviewed the medical records for 115 wounded soldiers who sustained a Type III open tibia fracture and tabulated the prevalence of deep soft-tissue infection and osteomyelitis in this group. We searched the Physical Evaluation Board (PEB) database to determine the disability ratings of soldiers with and without an infection and how many of each group were able to return to active duty service. The average percent disability rating between soldiers with and without infection was compared using an unpaired *t* test. RTD rates between soldiers with and without an infection were compared using a  $\chi^2$  method of analysis. Significance level was set at  $P < 0.05$  for all tests.

**Results:** 46 of the 115 soldiers (40%) had an infectious complication of their fractured limb. 45 soldiers (39%) had a deep soft-tissue infection, and 29 (25%) had osteomyelitis. 21 soldiers were able to return to active duty military service, while 94 could not and were medically retired. Of those who returned to duty, five (24%) had an infection; there were five deep soft-tissue infections and two cases of osteomyelitis. Of those medically retired, 41 (44%) had an infection; 40 had deep-tissue infections and there were 27 cases of osteomyelitis. The average percent disability among soldiers with infection was 55%, compared to 47% for those who were not infected. This demonstrated a weak trend toward increased disability among soldiers experiencing infectious complications ( $P = 0.1407$ ). Soldiers who experienced any type of infectious complication ( $P = 0.0470$ ) and having osteomyelitis ( $P = 0.0335$ ) had a lower chance of returning to duty compared with those who had no infection. Having a deep soft-tissue infection alone also showed a strong trend toward decreasing a soldier's chance of returning to duty ( $P = 0.0558$ ). Infection contributed to the indication for amputation in 10 soldiers with 11 amputated limbs. No soldier with an amputated limb returned to duty.

**Conclusion:** Soldiers with infectious complications following a Type III open tibia fracture have a significantly lower rate of returning to active duty military service than those without infectious complications. Additionally, soldiers experiencing infectious complications following their severe lower extremity trauma have a trend toward higher disability ratings, which is consistent with the civilian literature. These results indicate that the presence of

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infection contributes to a soldier's overall level of disability and likelihood of returning to duty, and that the initial prevention of orthopaedic infection may affect holistic patient outcome. Further studies are required to further elucidate the factors that contribute to RTD and overall disability following severe lower extremity trauma so that we may better serve our wounded soldiers.



### Quantification of Anterior Cortical Bone Removal and Intermeniscal Ligament Damage at the Tibial Nail Entry Zone

Jesse E. Bible, MD; Ankeet A. Choxi, BE; Sravan Dhulipala, BS; Jason M. Evans, MD; Hassan R. Mir, MD;

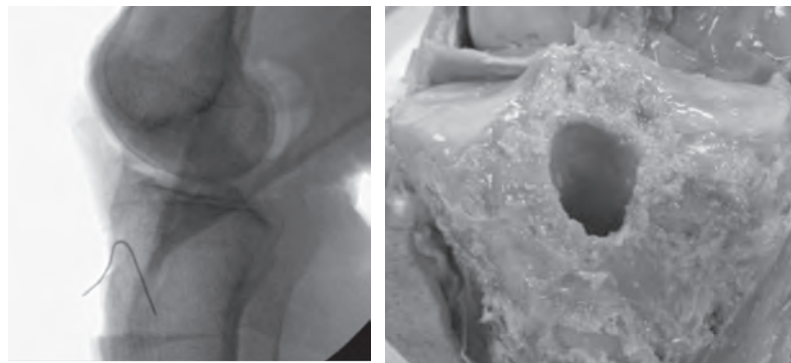
Vanderbilt Orthopaedic Institute, Nashville, Tennessee, USA

**Purpose:** Anterior knee pain is common after tibial intramedullary nailing with multiple postulated contributing factors. Anterior cortical bone removal at the nail entry zone has been shown to alter the biomechanical properties of the proximal tibia. However, no study has quantified the amount of anterior bone removed during tibial nail entry portal creation. The purpose of this study was to quantify the amount of anterior bone removed around the tibial nail entry zone and to assess damage to adjacent intra-articular structures.

**Methods:** The study was performed using 14 cadaveric knees. Medial peritendinous approaches were made with a 3-cm incision, and a guide pin was placed in the anatomic safe zone using fluoroscopic guidance with the knee in flexion. A 12.5-mm entry reamer was used to open the medullary canal. The soft tissues were then carefully removed, and any damage to intra-articular structures was recorded. Using calibrated digital images, the size of the osseous defect created in the proximal tibia was measured.

**Results:** The surface area of bone removed from the proximal tibia was  $208.4 \pm 37.3 \text{ mm}^2$ , which substantially differs from the area that would be removed if the entry hole was perfectly round ( $122.7 \text{ mm}^2$ ). The additional bone removed was found to be due to the oblong shape of the entry zone, with the average portal dimension  $14.2 \pm 1.1 \text{ mm}$  in the medial/lateral plane and  $18.7 \pm 3.1 \text{ mm}$  in the anteroposterior plane. The entry portal on average extended to  $11.6 \pm 7.1 \text{ mm}$  above the tibial tubercle. The intermeniscal (IM) ligament was damaged in 79% of knees, with partial disruption in 50% and complete disruption in 29%.

**Conclusion:** The results of this study suggest that a substantial amount of anterior tibial bone is removed during nail entry portal creation. IM ligament damage was also found to occur adjacent to the majority of tibial nail entry zones. Avoidance of both anterior tibial cortical bone removal and IM ligament damage may not be possible with current nailing techniques due to size and geometrical constraints. Further clinical studies are needed to determine which factor may be more contributory to knee pain.



**Figures**  
Lateral radiograph and AP photograph illustrating anterior tibial cortex loss.

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**Posterolateral Depression in Tibial Plateau Fractures:  
A Novel Technique for Reduction and Fixation**

*Adam A. Sassoon, MD; Joseph R. Cass, MD; William W. Cross, MD; Michael E. Torchia, MD; Stephen A. Sems, MD;*  
*Mayo Clinic, Rochester, Minnesota, USA*

**Background/Purpose:** Posterior depression of the lateral tibial articular surface can be difficult to elevate and support with fixation and bone graft. Progressive collapse following open reduction and internal fixation (ORIF) has been described and can lead to failure in treatment. A standard anterolateral approach to the tibia may not allow direct reduction and stabilization of posterolateral joint depression. Posterolateral approaches to the tibial plateau have been described and allow direct reduction of the articular depression; however, these approaches require dissection close to the common peroneal nerve and may require a proximal fibular osteotomy. This work describes the operative technique for the use of an intraosseous fibular allograft in select cases of depressed posterolateral tibial plateau fractures, allowing both reduction of the joint and stabilization of the articular segment through a single, familiar approach.

**Methods:** Following IRB approval, a retrospective review was performed of the first 11 cases at our institution where a fibular shaft allograft was used to reduce and support posterolateral joint depression associated with an acute tibial plateau fracture. An anterolateral approach was used in all instances. Bicondylar fractures were treated with an additional posteromedial approach as indicated. Fracture classification according to the OTA and Schatzker systems were noted. Preoperative radiographic measurements were used to quantify the joint depression and were compared to subsequent postoperative measurements obtained immediately after surgical intervention and at the most recent follow-up. Time to union and postoperative knee range of motion were also noted.

**Results:** Between 2008 and 2010, 11 patients with a mean age of 50.5 years were treated with posterolateral fibular strut augmentation. This included 5 bicondylar, 4 depression, and 2 split-depression fractures. The average follow-up was 11 months. All fractures united at a mean of 3.4 months. The average joint depression, measured on plain radiographs, was 11 mm prior to definitive surgical intervention and 0.8 mm at the most recent follow-up. The mean postoperative range of motion was 2° to 119°. Two complications occurred. One patient developed postoperative arthrosis with 3 mm of recurrent joint collapse. Another patient developed a postoperative infection at 6 months, following fracture union, which required removal of all hardware and the fibular allograft. This patient subsequently developed a 6-mm collapse of her joint line.

**Conclusions:** Fibular shaft allografts can be used in the treatment of posterolateral joint depression caused by tibial plateau fractures with clinical success. The graft serves as a reduction tool and structural support during fracture union. The results of this case series demonstrate a union rate of 100% and maintenance of the restored joint line in 82% of cases without further patient morbidity attributable to an additional posterolateral approach.

## Do Open Fractures Influence Postoperative Length of Stay? A Retrospective Review of Isolated Femur and Tibia Fractures at a Level I Center

Jake McClure, BS; Tyler Armstrong BS; A. Alex Jahangir, MD; Jesse Ehrenfeld, MD, MPH; William T. Obrensky, MD, MPH; Khensani N. Marolen, MPH; Manish K. Sethi, MD; Vanderbilt University Medical Center, Nashville, Tennessee, USA

**Background/Purpose:** Diaphyseal fractures of the tibia and femur, both open and closed, are a significant part of the practice of any orthopaedic trauma surgeon. While increased hospital length of stay (LOS) is a clear cost driver in American health care, the specific influence of isolated open tibial and femoral fractures on LOS has not been previously investigated. The purpose of this study is to investigate the relationship between isolated open and closed diaphyseal femur and tibia fractures and patient LOS.

**Methods:** After receiving IRB approval, we performed a chart review to identify femur and tibia fractures fixed by intramedullary fixation (CPT 27506 and 27759) at a major Level I trauma center from January 2004 to December 2006. Patients who sustained other injuries were excluded, leaving only patients with isolated femur and tibia fractures. Fracture characteristic (open vs closed), the need and type of muscle coverage, as well as potential confounding variables including American Society of Anesthesiologist (ASA) physical status classification, age, gender, race, and hospital LOS were obtained. Multiple regression analysis was then conducted. Financial data for a 1-day inpatient stay was obtained from financial services and estimated to be \$4503 per inpatient day.

**Results:** We identified and reviewed 1040 charts of patients with diaphyseal tibia and femur fractures. 741 of these patients had isolated injuries of the tibia or femur only. This group of patients included 521 (459 closed, 62 open) femur fractures and 220 (106 closed, 114 open) tibia fractures. Among the open tibia fracture group, 14 patients required flap coverage. We adjusted for age, gender, race, and ASA physical status classification using multiple regression and demonstrated that increased LOS was strongly associated with open fractures. Adjusted LOS was significantly higher in open femur (4.43 days) than closed femur fractures (3.39 days) ( $P = 0.0222$ ). Adjusted LOS was also significantly higher in open tibia (5.7 days) than closed tibia fractures (3.33 days), ( $P < 0.001$ ). Among the open tibia fracture group, when comparing patients who had wounds that were primarily closed with those who had flaps, there was a significant difference in LOS with the patients undergoing flaps staying longer (8.55 days vs 5.31 days,  $P = 0.0012$ ). Utilizing financial data and considering the increased LOS in the open femur fracture group as compared to the closed femur fractures, open femur fractures cost the institution on average \$4503 more per patient. Similar calculations in the open versus closed tibia group demonstrate an increased cost of \$9000 per patient. When considering open tibia fractures that received flap coverage as compared to the open tibia fractures that were primarily closed, the costs increase by \$13,500.

**Conclusions:** Our study is the first to demonstrate the increased resources utilized to provide care for open fractures. It is important for surgeons and institutions to develop a more nuanced understanding of the impact of these injuries, presented in this study, for resource allocation, budgeting, and contract negotiations.

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### Prospective Randomized Evaluation of Outcomes With Different Tibial Nail Entry Portals

Michael P. McClincy, MD; Dana J. Farrell, BS; Peter A. Siska, MD; Gary S. Gruen, MD; James J. Irrgang, PT, PhD, ATC, FAPTA; Ivan S. Tarkin, MD;

Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

**Purpose:** Knee pain and dysfunction are common iatrogenic complications after tibial nailing. Choice of entry portal site and exposure may contribute to this common postoperative finding. In the current study, a prospective randomized trial was designed to determine whether the traditional high intracapsular starting point or lower extracapsular entry portal was superior with regard to postoperative pain and functional outcomes.

**Methods:** 29 patients with closed tibial shaft fracture were prospectively followed for a total of 24 months. All patients underwent intramedullary nailing and were randomized into two groups based on starting point with either a high intracapsular start point (N = 12) or an extracapsular start point (N = 17). All cases were performed by a fellowship-trained orthopaedic traumatologist. No significant differences were noted between patient groups with respect to age or mechanism of injury. Outcome measurements included the American Knee Society Score (AKS), the 36-Item Short-Form Survey (SF-36), and the Knee Injury and Osteoarthritis Outcome Score (KOOS), which were measured at 2 weeks, 6 weeks, 6 months, 12 months, and 24 months postoperatively.

**Results:** Neither the intracapsular or extracapsular starting point for tibial nailing demonstrated a superior result. No statistically significant differences were observed between the groups according to the AKS, SF-36, or KOOS scores ( $P > 0.05$ ) at any timepoint. Average AKS scores at 6 months were 85.4 (87.7 intracapsular, 83.6 extracapsular). At this time point, 70% of patients had excellent outcomes (80-100), 20% had good outcomes (70-79), and 1 had a fair outcome (60-69). With scores specifically related to patient-reported pain (SF-36 Bodily Pain score and the KOOS Pain score), no differences were detected, with an average of 64.9 (68.5 vs 61.1) and 80.8 (80.0 vs 76.5), respectively. Complications included two nonunions treated successfully with exchange nailing. No malunions or infections were recorded.

**Conclusion:** Both “traditional” intracapsular high starting points and a lower extracapsular entry portal for nailing of tibia shaft fracture yield similar outcomes with regard to patient function and pain.

**Recombinant Human Platelet-Derived Growth Factor-BB (rhPDGF-BB) and Beta-Tricalcium Phosphate ( $\beta$ -TCP) in Foot and Ankle Fusions***Michael. S. Pinzur, MD<sup>1</sup>; Christopher W. DiGiovanni, MD<sup>2</sup>; Sheldon S. Lin, MD<sup>3</sup>;*<sup>1</sup>*Loyola University Medical Center, Maywood, Illinois, USA;*<sup>2</sup>*Brown University, Providence, Rhode Island, USA;*<sup>3</sup>*New Jersey Medical School, Newark, New Jersey, USA*

**Background/Purpose:** Joint fusion employing autogenous bone graft (autograft) remains a mainstay of management for many foot and ankle problems, particularly end-stage arthritis and deformity. Graft harvest, however, can lead to additional perioperative morbidity and increased cost. We tested the hypothesis that purified recombinant human platelet-derived growth factor BB homodimer (rhPDGF-BB) combined with an osteoconductive matrix (beta-tricalcium phosphate [ $\beta$ -TCP]) would be a safe and effective alternative to autograft.

**Methods:** 434 patients were enrolled in 37 clinical sites across North America in a prospective, randomized (2:1), controlled, blinded, noninferiority clinical trial to compare the safety and efficacy of the combination rhPDGF-BB and  $\beta$ -TCP (Augment Bone Graft) to autograft in patients requiring hindfoot or ankle arthrodesis. Radiologic, clinical, functional, and quality-of-life end points were assessed through 52 weeks postoperatively.

**Results:** Regarding the primary end point, 61.2% (159 of 260) of the rhPDGF-BB/ $\beta$ -TCP-treated patients (66.5% [262 of 394] of the joints) and 62.0% (85 of 137) of the autograft-treated patients (62.6% [127 of 203] of the joints) were fused as determined by 6-month CT scan assessment ( $P < 0.05$ ). Clinically, 86.2% (224 of 260) of the rhPDGF-BB/ $\beta$ -TCP-treated patients (88.3% [348 of 394] of the joints) were considered healed at 52 weeks, compared to 87.6% (120 of 137) of the autograft-treated patients (87.2% [177 of 203] of the joints) ( $P < 0.01$ ). Overall, 14 of 16 secondary end points at 24 weeks and 15 of 16 secondary end points at 52 weeks demonstrated statistical noninferiority between groups, and patients treated with rhPDGF-BB/ $\beta$ -TCP were found to have an improved safety profile.

**Conclusions:** In patients requiring hindfoot or ankle arthrodesis, treatment with rhPDGF-BB/ $\beta$ -TCP resulted in comparable fusion rates and fewer side effects as compared to treatment with autograft.

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**Effect of Bone Morphogenetic Protein, Granulocyte–Colony Stimulating Factor, and Bone Marrow Stem Cells on Fracture Healing in Rats with Osteoporosis:****A Comparative Study**

Vijay G. Goni, MD; Kishan R. Bhagwat, MD; Bikash Medhi, MD;

M. Thungapathra, MD; Ashim Das, MD;

Post Graduate Institute of Medical Education & Research (PGIMER), Chandigarh, India

**Background/Purpose:** Osteoporotic fracture is known to be deficient in local concentration of stem cells and growth factors. Our goal was to study the effect of bone morphogenetic protein (BMP), granulocyte–colony stimulating factor (G-CSF), and bone marrow stem cells on osteoporotic fracture healing.

**Methods:** 48 female Wistar rats were divided into groups of 6 rats each. Except for the control rats (Group A), all other rats underwent ovariectomy. Four weeks after this surgery, these rats represented the estrogen deficiency osteoporotic model. A fracture was created in the left tibia of all rats and stabilized with intramedullary device. In Group A (normal controls) and Group B (osteoporotic controls), only an intramedullary device was used. In Group C, oral alendronate was given weekly for 4 weeks. In Group D, bone marrow stem cells derived from donor osteoporotic rats (Group H) were administered locally. In Group E, fracture fixation was supplemented by local infiltration of bone marrow stem cells and recombinant human BMP-2 (rhBMP-2) in collagen sponge. In Group F, BMP was infiltrated locally and subcutaneous injection of G-CSF was given for 5 days. In Group G, bone marrow stem cells and BMP were used locally and G-CSF was given subcutaneously. Four weeks after creating the fracture and treating it with various modalities, all the rats were sacrificed and radiographs of the fractured limb were obtained, bridging callus studied histologically, and serum VEGF (vascular endothelial growth factor and TGF (transforming growth factor)– $\beta$ 1 levels were estimated to evaluate fracture healing.

**Results:** Mean radiological grades: Group B, 2.17 to Group G, 4.17 (Group B < C < A < D < E = F < G). Mean histological grades: Group B, 3.33 to Group G 7.00 (Group B < C = D < A < E < F < G). Serum VEGF levels: Group B, 8.34 pg/mL to Group A 14.79 pg/mL (Group A > E > G > F > D > C > B) and TGF- $\beta$ 1 levels: Group D, 73.83 ng/mL to Group A 112.32 ng/mL (Group A > G > C > F > B > E > D).

**Conclusions:** Addition of local rhBMP-2 along with bone marrow stem cells improves osteoporotic fracture healing significantly ( $P < 0.05$ ) and the healing pattern is better than the normal fracture healing, which is further augmented by giving systemic G-CSF ( $P < 0.05$ ). Oral alendronate and local infiltration of stem cells improve osteoporotic fracture healing, although statistically insignificant ( $P > 0.05$ ).



## Conversion from External Fixator to Intramedullary Nail Impairs Fracture Healing Particularly After a Severe Trauma

S. Recknagel<sup>1</sup>; R. Bindl<sup>1</sup>; T. Wehner<sup>1</sup>; C. Ehrnthaller<sup>1</sup>; F. Gebhard<sup>2</sup>;  
M. Huber-Lang<sup>2</sup>; L. Claes<sup>1</sup>; A. Ignatius<sup>1</sup>;

<sup>1</sup>Institute of Orthopaedic Research and Biomechanics, Center of Musculoskeletal Research, University of Ulm, Ulm, Germany

<sup>2</sup>Department of Traumatology, Hand-, Plastic-, and Reconstructive Surgery, Center of Musculoskeletal Research, University of Ulm, Ulm, Germany

**Introduction:** In polytraumatic patients second hits, e.g. second surgical interventions, are known to potentiate the posttraumatic systemic inflammatory response, thus increasing the risk of multi-organ dysfunction. Generally, in severely injured patients fractures of the extremities are initially treated with an external fixator, which is replaced by an intramedullary nail in a second surgical intervention as soon as the immunological status of the patient is considered as stable. Recently, we demonstrated that a severe trauma impaired the healing of fractures, which were stabilized by an external fixator during the entire healing period. The question arises, whether the switch to an intramedullary nail increases the posttraumatic systemic inflammatory response in terms of a second hit and leads to a further impairment of bone healing.

**Methods:** 42 male Wistar rats received an osteotomy of the right femur, which was initially stabilized by an external fixator (FX). At the same time, half of the animals underwent a blunt chest trauma (TXT). After 4 days the external fixator was replaced by an intramedullary locking nail (IMN; Fig. 1) in a second surgical intervention in half of the animals of the two groups. The animals were harvested 40 and 47 days after the first operative procedure. The groups were divided as follows: (A) FX, 40 days (n=8); (B) FX+IMN, 40 days (n=5); (C) FX+TXT, 40 days (n=7); (D) FX+TXT+IMN, 40 days (n=7); (E) FX+IMN, 47 days (n=7); (F) FX+TXT+IMN, 47 days (n=8) (Table 1). Blood was taken from the animals in order to measure the systemic inflammatory response by analyzing the C5a serum level 0, 6, 24, and 72h after the first surgery and 6, 24, and 72h after the second surgery. The fracture healing outcome was determined by biomechanical testing (three-point-bending test) of the healed femora and by  $\mu$ CT analysis. The animal experiment was performed according to international regulations for the care and use of laboratory animals, and approved by the local ethical committee (Regierungspräsidium Tübingen, Germany). Statistics: Student's t-test. Level of significance:  $p < 0.05$ .

Table 1: Experimental design

Intervention	Group					
	A	B	C	D	E	F
External Fixator	x	x	x	x	x	x
Blunt chest trauma			x	x		x
Conversion to intramedullary locking nail		x		x	x	x
Healing time	40 days	40 days	40 days	40 days	47 days	47 days

**Results Section:** The C5a serum levels were significantly increased 6 and 24h after the first surgery and decreased to pre-operative values after 72h with no significant differences between the groups with and without thoracic trauma (groups B, D). However, the blunt chest

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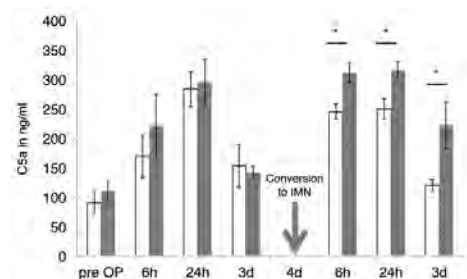
trauma significantly increased C5a concentrations 6 (p=0.02), 24 (p=0.02) and 72h (p=0.04) after the second surgical intervention (groups B, D; Fig. 2). Whereas the fracture calli of the rats treated with an external fixator during the entire healing time (groups A, C) almost attained the stiffness of the contralateral intact femur, the switch to the intramedullary nail 4d after the first surgery (groups B, D) decreased the bending stiffness considerably, with no significant differences between animals that had a thoracic trauma nor between those without after 40 days (Fig. 3). After 47 days flexural rigidity was still reduced in group E compared to group A, demonstrating the negative influence of the second operation on fracture healing. In the rats with a severe trauma, the second intervention (group F) slightly decreased the bending stiffness in comparison to rats without a thoracic trauma (Group E; Fig. 3).  $\mu$ CT measurements confirmed the biomechanical results, indicating inferior callus quality in animals subjected to a second surgical intervention, particularly in combination with the blunt chest trauma (results not shown).

**Discussion:** This study showed that after a severe trauma the conversion of the fracture fixation from an external fixator to an intramedullary nail could provoke a second hit as demonstrated by significantly increased C5a serum concentrations up to 3 days after the second surgical intervention. Furthermore, the switch to an intramedullary nail 4 days after the first surgery led to considerable impairment of the fracture healing outcome 40 days after the first surgery. Even 7 days later after a healing time of 47 days, fracture healing in animals subjected to a conversion from external fixator to secondary intramedullary nail was still delayed, particularly in combination with the blunt chest trauma, indicating that the accumulation of second hits after multi injury could lead to a further aggravation of the fracture healing outcome.

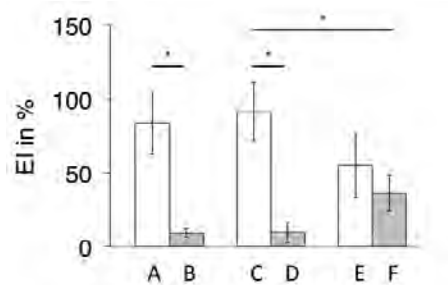


**Figure 1:** X-ray of a femoral fracture stabilized by an intramedullary locking nail after conversion from an external fixator 4 days post OP.

**Figure 2:** Serum C5a levels of animals subjected to a thoracic trauma (grey columns) or was not (white columns) 0h, 6h, 24h and 3d after the first surgery and 6h, 24h and 3d after the conversion to an intramedullary nail. n=5-8; \*p<0.05







**Figure 3:** Flexural rigidity (EI) of the fracture callus of groups A-F. n=5-8; \*=p<0.05

**Significance:** This study provides new insights into the pathophysiology of impaired bone healing in polytraumatic patients.

**Acknowledgements:** This study was kindly supported by the German Research Foundation (DFG, No. KFO200). None of the authors have any conflicts of interest.

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**Functional Outcome of Patients With Long-Bone Fracture Treated With External Fixation and Open Interlocked Intramedullary Nailing With Bone Grafting***Raymar L. Sibonga, MD; Co-Authors \_\_\_\_\_?**Institution(s) \_\_\_\_\_?*

**Methods:** In this case series study we reviewed 11 patients, 4 women and 7 men aged 18 to 78 years, with long-bone fractures previously treated by external fixation with subsequent conversion to open interlocked intramedullary nailing using the SIGN (Surgical Implant Generation Network) implant and instrumentation with bone grafting, coupled with aggressive postoperative rehabilitation at Western Visayas Medical Center, Iloilo City, Philippines from March 2011 to December 2011. The treatment outcome and functional outcome compared with the general population were then measured using the AAOs (American Academy of Orthopaedic Surgeons) Lower Limb Core Scale standardized and normative scores respectively.

**Results:** Of the 11 patients who were included in the sample population, 2 patients had loosening of 1 screw; none had nonunion and 1 underwent secondary procedure (insertion of longer nail). All had some degree of shortening that was already present prior to intramedullary nailing; in five it was more than 2 cm, and none had further shortening after internal fixation and until fracture union. The total gain in length after intramedullary nailing was 8.5 cm with a mean of 0.77 cm (range, 0-2). None had neurologic injury following acute gain in length. None had deep infections; 2 had superficial wound infections. The mean duration of external fixation was 354.54 days (range, 90-1195). The mean duration from removal of external fixation to application of SIGN implant and instrumentation was 99 days (range, 14-300). The mean improvement in knee flexion is 39° (range, 20°-70°), the mean standardized score is 83.36 (range 67-96), and the mean normative score is 44.81 (range, 33-54).

**Conclusions:** This study showed that open interlocked intramedullary nailing with bone grafting in long-bone fractures treated previously with external fixation coupled with aggressive rehabilitation can achieve acceptable results, and functional outcomes when compared with the general population.

**Internal Fixation Augmented With Antibiotic-Loaded Bone Cement Beads and Rods in Delayed/Neglected Open Complex Fractures of the Distal Femur***Harpal Singh Selhi, MD; Co-Authors \_\_\_\_\_?**Institution(s) \_\_\_\_\_?*

**Background/Purpose:** Interventions in management of open fractures include splinting, antibiotic administration, tetanus prophylaxis, surgical débridement and irrigation (D&I), fracture reduction and stabilization, and definitive soft-tissue coverage as a means of minimizing the risk of acute infection. Although a 6-hour rule for D&I of open fractures has been recommended, it appears that patients with open fractures may often be associated with a high-energy mechanism that can result in additional injuries including severe head or chest injury, which may prevent emergent or even urgent surgery due to hemodynamic instability and surgical risk. The literature on management of open fracture is mostly focused on tibial fractures and that too shaft fractures. There is rare mention of the femoral open fractures and negligible with focus on distal femoral fractures with or without articular involvement, none on those associated with severe head or chest injury causing the delay in the orthopaedic management of open fracture.

**Methods:** We report our series of five cases of open complex distal femoral fractures, which could not be taken up for emergent débridement and stabilization because of associated injuries. The patients had a delay in first surgical débridement of greater than 7 days from time of injury (average 11 days). These patients later underwent open reduction and internal fixation with distal femoral locking plate augmented with antibiotic-loaded bone cement beads and rods.

**Results:** Two patients underwent débridement and stabilization with knee joint spanning external fixator as first procedure and later converted to locking plate fixation and antibiotic beads and/or rods. Two patients underwent débridement and skeletal traction followed by débridement and locking plate fixation and antibiotic beads and/or rods. One patient presented to us 36 hours after injury, he underwent débridement and stabilization with knee joint spanning external fixator as first procedure and later converted to locking plate fixation and antibiotic beads and/or rods. Of these five, one patient progressed to union uneventfully. In the other three, the antibiotic-impregnated beads/rods were removed and autogenous bone grafting performed. In the fifth patient the antibiotic rods are in situ and his fracture is in process of healing.

**Conclusions:** The open distal femoral fractures are high-energy fractures with intra-articular involvement and are commonly associated with severe head and chest trauma. Therefore, management of open fracture including débridement, stabilization, and soft-tissue coverage take a back seat. In view of comminution and articular involvement, internal fixation remains the method of choice thus further adding to the difficulty in management of these injuries. Since deep tissue cultures are neither sensitive nor specific in this situation, we followed a case-specific approach: surgical débridement(s), fixation with distal femoral locking plate and antibiotic-loaded cement beads and rods to fill up the dead space in distal femoral metaphysis. We recommend a study with more cases in center(s) that cater to this patient population to validate the results.

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### Less Invasive Stabilization System: Is This the Ultimate Solution for Distal Femur Fractures?

*Bruno Bellaguarda Baptista; Ricardo Antonio Tavares; João Batista Manzolli Torres; Mauricio Kfuri, MD; DEGREES???*  
*Ribeirao Preto Medical School, São Paulo University, São Paulo, Brazil*

**Purpose:** Less invasive stabilization system (LISS) has been seen as the state of art for distal femoral fractures, especially in the elderly. Some reports, however, point out the relative high prevalence of bone healing disturbances and even malignment, especially in more simple fracture patterns. Our hypothesis is that LISS does not help to improve fracture reduction and is associated with high rates of primary and secondary malalignment.

**Methods:** From April 2002 to December 2010, 45 patients presenting 46 fractures classified as AO/OTA 33A and 33C were operated on at our institution. We have reviewed all patient data in this retrospective cohort with attention to final alignment of lower limb and bone healing process.

**Results:** The majority of our patients were male (60%), sustaining high-energy trauma and revealing open fractures (56.5%). AO/OTA 33C-type fractures occurred in 76% of our cases. Time of follow-up was on average 20 months and fractures healed primarily in 87% of cases. Average healing time was 5.3 months. Almost half of our cases were considered as having a malalignment, especially in the frontal plane.

**Conclusions:** New implants do not necessarily result in better outcomes. Less invasive stabilization systems are really useful but do not make fracture reduction easier. When using new implant technologies, the surgeon must be aware that such devices do not obviate the need to follow the principles of internal fixation.

**Floating Knee and Retrograde Femoral Nail: Is This Combination Reliable?**

*Bruno Bellaguarda Baptista; Leonardo Mascarenhas; Marcelo Castiglia; Mauricio Kfuri, MD;*  
**DEGREES???**

*Ribeirao Preto Medical School, São Paulo University, São Paulo, Brazil*

**Purpose:** Retrograde femoral intramedullary nailing is considered to be an acceptable option for managing femoral fractures in floating knee injuries. Our hypothesis is that this technique in such cases is associated with high rates of bone healing disturbances.

**Methods:** From March 2002 to February 2011, 63 patients presenting 64 femoral fractures were treated with retrograde femoral nails. Out of this group, 24 patients sustained floating knees and became our retrospective cohort. Time of healing, immediate postoperative alignment, late postoperative alignment, knee complaints, number of secondary surgeries, and type of secondary surgery, when this applied, were the variables we took into consideration.

**Results:** All patients with floating knees injuries sustained high-energy trauma. 71% of our cases were caused by motorcycle accidents; however, the majority of them (79%) were closed fractures. All except one were AO/OTA 32 fractures and 87.5% of our patients were treated in a staged protocol, following the principles of damage control. Time elapsed between trauma and definitive surgery was on average 7 days and the average time of hospitalization 21 days. Nail diameter was 10 mm in 19 patients. Follow-up time varied from 8 to 51 months, with an average of 24.9 months. Time elapsed until the patient was able to completely bear weight was on average 4.6 months. Nine patients (37.5%) presented healing disturbances characterized either by absence of callus formation or implant breakage. All of them needed a reoperation either for dynamization of intramedullary nail or even biomechanical principle and technique exchange.

**Conclusions:** Floating knees are challenging injuries commonly associated with complications. We registered high rates of femoral delayed union and nonunion in our series. We attribute these results to the use of unreamed femoral nails. In our series the use of retrograde femoral nail in floating knees did not appear to be a reliable technique concerning uneventful healing.

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### **Intramedullary Nailing for Pertrochanteric Fractures: Do We Really Need Traction Tables?**

Rogério Carneiro Bitar; *Mauricio Kfuri, MD; DEGREES???*

Ribeirao Preto Medical School, São Paulo University, São Paulo, Brazil

**Purpose:** Orthopaedic tables are considered a standard tool for positioning patients who are to be operated on for proximal femoral fractures. Not every hospital in Latin America is equipped with such tables and not every surgical team is used to such devices. Our hypothesis is that with special patient positioning at radiolucent conventional tables it is possible to achieve results comparable to those reported while using orthopaedic tables.

**Methods:** In this retrospective cohort, we reviewed the data of 14 patients who sustained pertrochanteric femoral fractures and were submitted to fixation with intramedullary implants. All these patients were positioned in a lateral oblique decubitus, with 45° of inclination in relationship to the plane of the radiolucent table. All of them followed the same protocol for acquiring intraoperative images of the femoral neck and the femoral diaphysis. The analyzed variables were time of surgery, intra- and perioperative complications, and final position of the cephalic screw in relationship to the tip apex distance (TAD) described by Baumgaertner.

**Results:** TAD was on average 18. None of the cases had a TAD greater than 25. Average operation time was 115 minutes, including time of anesthetics. We did not have any varus malalignment. No cases of infection were registered. No cases of late mechanical complications have been noticed in this case series.

**Conclusions:** More important than the operation table is the patient positioning. This positioning has to ensure appropriate views of the femoral neck and femoral diaphysis in order to result in appropriate fracture reduction and implant placement.

## Management of Open Tibia Fractures in the Developing World Using the SIGN Intramedullary Nail

*Daniel Galat, MD;*

*Tenwek Hospital, Bomet, Kenya*

**Purpose:** This study was undertaken to evaluate the outcomes of patients in a developing country with open tibia fractures stabilized with the Surgical Implant Generation Network (SIGN) intramedullary nail.

**Methods:** A retrospective analysis of prospectively collected data entered into the SIGN online database for all open tibia shaft fractures treated with the SIGN nail at a rural hospital in southwest Kenya was conducted. Clinical and radiographic data from follow-up visits were reviewed, and rates of deep infection were determined, including the need for additional surgery. Timing from injury to intravenous antibiotic administration and to first surgical débridement for all patients were evaluated.

**Results:** From November 2008 to January 2012, 98 open tibia shaft fractures were treated with the SIGN intramedullary nail at our mission hospital. According to the fracture classification of Gustilo and Anderson, 18 fractures were type I, 57 were type II, 17 were type IIIa, 5 were type IIIb, and 1 was type IIIc. 70% of patients were male, and the mean patient age was 36.9 years (range, 16-90). Deep infection occurred in 17 fractures (17.4%). Infection rates by Gustilo and Anderson type were 11.1% for type I, 10.5% for type II, and 39.1% for type III. Among the 17 fractures with deep infection, 14 (82%) required additional surgical management, with débridement(s) and/or nail removal at fracture union in 13 cases and below-knee amputation in 1 case. When comparing patients who developed deep infection with those who did not, there were no significant differences in mean time from injury to intravenous antibiotic administration or to initial surgical débridement.

**Conclusions:** Open tibia shaft fractures can be managed effectively using the SIGN intramedullary nail system with an overall deep infection rate of approximately 17%. When deep infection occurred, additional surgical management was required in the majority of cases. In our series, infection rates did not appear to be correlated with timing from injury to antibiotic administration or to initial surgical débridement (although the importance of these factors has been demonstrated previously).

**Significance:** This retrospective analysis of prospectively-gathered data from a large series establishes the rates of deep infection following fixation of open tibia fractures using the SIGN intramedullary nail system, which is utilized extensively in the developing world.

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## One Prone Position, Double Incision, and Triple Fixation for the Treatment of Trimalleolar Fractures

*Baoqing Yu, MD;*

*Department of Orthopaedics, Changhai Hospital, The Second Military Medical University, Shanghai, China*

**Purpose:** The purpose of this paper is to report a simplified method for the treatment of trimalleolar fractures that has proved very useful in the our experience: open reduction and internal fixation (ORIF) of trimalleolar ankle fractures with one prone position (draping once), double incision, and triple fixation. Our objective was to evaluate the efficacy and prognosis of the posterolateral approach combined with medial approach for treatment of trimalleolar fracture.

**Methods:** From 2005 to 2010, 39 patients with trimalleolar fracture were treated by ORIF on prone position with single draping. The operative procedure was divided into two steps, the posterior malleolar fractures fixed with cannulated screws and lateral malleolar fractures fixed with plate through posterolateral approach, the medial malleolar fracture fixed with cannulated screw through anterior-medial approach with the flexion of the knee. The bone union and the stability of the implants were observed during the follow-up.

**Results:** The average operation time was  $90.0 \pm 3.4$  minutes (range, 60-120 min), which was significantly different compared with the other 40 cases with trimalleolar fractures treated by ORIF with the combination of supine and prone position by draping twice. The postoperative hospital stay was  $6 \pm 0.8$  days (range, 5-7 days). All the patients were followed up for an average  $18.6 \pm 2.1$  months (range, 12-36 months). The incisions of all patients had primary healing. There were no malunions, redisplacement, implant loosening, internal fixation failure, nonunion, or infection. The healing time of the fracture was an average  $3.2 \pm 0.4$  months (range, 3-4 months). All the patients achieved normal gait at the last follow-up.

**Conclusion:** The therapeutic method with one prone position, double incision, and triple fixation is a feasible and effective approach for trimalleolar fracture. The one prone position can provide efficiency enormously to the orthopaedic surgeon by saving operative time.



## **Ankle Fracture Fixation With a Novel Intramedullary Photodynamic Polymeric Bone Pin: A Case Series Review**

*Thomas Gausepohl, MD;*

*Klinikum Vest, North Rhine-Westphalia, Germany*

**Background/Purpose:** Ankle fractures in the elderly population are a common problem, with an incidence rate of approximately 187 per 100,000 people each year. The presence of poor bone quality related to osteoporosis combined with critical soft-tissue condition can provide technical challenges during fracture fixation. A novel minimally invasive intramedullary implant formed by the use of a balloon catheter and a light curable monomer recently received CE (European conformity) mark clearance for use in low load-bearing fracture treatment. The device forms a patient-customized, intramedullary polymer implant. The balloon catheter is inserted into the medullary canal and positioned across the reduced fracture. Once in correct alignment and position, it is infused with a biocompatible photodynamic liquid monomer via a standard syringe. An integrated visible light curing system is used to quickly polymerize the liquid monomer within the confines of the balloon to form a strong hardened bone stabilization pin. The purpose of this study is to report on the safety and performance of the bone pin when used to treat ankle fractures.

**Methods:** The first 15 patients treated with a polymeric bone pin were assessed through up to 1 year follow-up for pain, range of motion, time to weight bearing, and clinical and radiographic healing. Pain was assessed by the request and use of analgesics, and by palpation of the fracture. Radiographs were obtained prior to surgery, postoperatively, and at every follow-up visit until clinical healing was defined as the return to prefracture function with no pain on palpation. Radiographic healing was defined as three of four cortices demonstrating bridging. Patients were followed for a minimum of 6 weeks and a maximum of 1 year posttreatment.

**Results:** 12 female and 3 male osteoporotic patients were treated for ankle fractures from June 2011 until February 2012. The average age at the time of surgery was 84 years. 13 patients presented with unilateral fractures, and 2 patients presented with fractures of the tibia and fibula. The surgical incision was bandaged, and no further casting or bracing was used for patients with isolated fibula fractures. Patients with tibia and fibula fractures were provided with a walking hook for support. All patients were full weight bearing on the second postoperative day. Patients resumed activities of daily living upon discharge from the hospital. There were no intraoperative adverse events. There were no adverse device effects, no infections, and no secondary procedures performed on this patient cohort. Only over-the-counter analgesics were used to manage pain on an as-needed basis. Patients were clinically healed by the 6-week follow up visit, and were radiographically healed by the 3-month follow-up visit.

**Conclusions:** This series reports the use of a polymeric bone pin for ankle fracture fixation. The intramedullary device provides stability to the fractured bone, maintaining alignment during the healing process. The bone pin has been well tolerated in patients and has not been associated with complications. The use of the bone pin is associated with reduced

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recovery time and faster return to baseline mobility and further use and investigation is warranted for this product.

**Fracture Management in Mirwais Hospital, Kandahar, Afghanistan in 2010***Abdul Ghani Mesbah, MD, MS; Co-Authors \_\_\_\_\_?**Institution \_\_\_\_\_? Kandahar, Afghanistan*

**Background:** Kandahar Mirwais Hospital is a referral hospital in the Kandahar province of Afghanistan providing the surgical, obstetric/ gynecological, pediatric, internal medical, ophthalmologic, and ENT (ears, nose, and throat) care for the estimated 3.7 million people in five regions of Southern Afghanistan. The hospital is capable of 450 beds at the same time, including 180 of the surgical profiles for the general and emergency trauma surgery.

**Methods:** In 2010, 7250 trauma cases have received treatment in the hospital, as 3594 total value were children. Southern Afghanistan is a war-conflicted zone and the hospital regularly admits war-wounded patients. In 2010, 476 patients with different kinds of weapon injuries were treated. Limb fractures were treated by plaster of Paris casts, skeletal traction, Hoffmann II, AO, GexFix models of external fixation, and SIGN (Surgical Implant Generation Network) nails.

**Results:** 3228 noncomplicated fractures were treated by plaster of Paris and skeletal traction with closed reduction of the fractures. 47 limb amputations were performed due to extensive injuries. 291 external fixations and 95 SIGN nails were used for complicated fractures. External fixations were applied for 143 patients with lower limbs affected, 47 for upper limbs, and 17 for pelvic fractures. SIGN nails were used for fixation of 70 femurs, 22 tibias, and 3 humerus fractures in adult patients. Complications of external fixation were observed in 81 patients, such as joint stiffness (40), osteomyelitis (25), nonunion (12), and wound infection and fixation apparatus breakages. Four complications were observed during long-term patient follow-up for SIGN nails. Both nonunion and nail breakage were reported in one case, one bone nonunions, one joint stiffness, and one wound infection.

**Conclusion:** The results of SIGN nailing for long-bone fractures in Mirwais hospital are comparable with results published in the world medical literature.

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### Three Dimensional Fluoroscopy for Detection of Intra-Articular Hardware in a Proximal Humerus Fracture Model: A Laboratory Study

Yoram A. Weil, MD; Shaul Beyth, MD; Amal Khoury, MD; Meir Liebergall, MD; Ori Safran, MD;

Department of Orthopaedics, Hadassah Hebrew University Hospital, Jerusalem, Israel

**Background/Purpose:** Proximal humerus locking plates (PHLP) had significantly improved the treatment of displaced, osteoporotic proximal humerus fractures in recent years. Despite their relative success, they are not devoid of pitfalls and complications. One of the most commonly occurring adverse phenomena is penetration of hardware into the glenohumeral joint occurring between 5% and 25% of cases. Because the humeral head is a spherical structure, peripheral screws that are too long may be overlapped by the wider part of the humeral head and therefore missed in certain fluoroscopic views. The use of intraoperative three-dimensional (3D) imaging has been described in the past recent years. Theoretically, this modality might assist in detecting intra-articular hardware. Recently a computer system has emerged (C-InSight, Mazor ST), allowing the use of a conventional C-arm fluoroscope (CF) to produce CT-like intraoperative images with reduced cost and radiation dose. The aim of this study was to compare the performance of standard, four-image-view fluoroscopy with the C-InSight in a proximal humerus fracture model.

**Methods:** A zinc-sprayed proximal humerus Sawbone was affixed with a PHLP. Six different constructs were assembled using six cortical 3.5-mm locking head screws. In each specimen, either one screw, two screws, or none were inserted 2 mm proud of the articular surface. Each specimen was placed on a radiolucent table and imaged either with a standard two-dimensional fluoroscope in four-view standardized image sets or with the C-InSight system. According to a power analysis, a set of six scans per each specimen was performed, producing overall 36 sets of images per each modality. Screws were designated alphabetically according to their position in the plate (A-I). The 36 sets of fluoroscopic scans as well as the C-InSight scans were digitized and given to two blinded senior shoulder surgeons for evaluation. 18 duplicates of scans were also inserted in random order into the images given to the observers in order to assess intraobserver consistency and validity. Each observer was asked to identify whether one, two, or none of the screws were protruding into the joint. The following correlations were examined: interobserver agreement, intraobserver agreement (for the 18 repeat measurements), accuracy of each modality, and accuracies of both modalities. Absolute agreement for each observation was defined as the accurate detection and designation of either one or two penetrating screws while partial agreement was the correct identification of one out of two penetrating screws penetrating the joint.

**Results:** Observer A had an absolute agreement of 69.4% (compared with the truth) and partial agreement of 19.4% with CF with 11.1% absolute errors in detecting the penetrating screws. Using the C-InSight system, Observer A had an absolute detection of screws of 97.2% and partial agreement of 2.8% with no absolute errors ( $P < 0.01$ ). Observer B had an absolute agreement of 91.7% (compared with the truth) and partial agreement of 5.64% with CF with a 2.8% of absolute errors in detecting the penetrating screws. Using the C-InSight system, Observer B had an absolute detection of 100% with no errors ( $P < 0.01$ ).

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The interobserver validity using CF yielded an interclass coefficient (kappa value) of 0.806 and for the C-InSight a kappa value of 0.931. The intraobserver validity of the CF yielded a kappa value of 0.933 for Observer A and a kappa value of 0.738 for Observer B while the C-InSight yielded a kappa value of 1.00 for both observers.

**Conclusions:** In a proximal humerus fracture model, both good quality CF taken in four standardized views can detect most but not all instances of screw penetration into the humeral head. However, 3D fluoroscopy can maximize this detection capability. No errors and absolute correct intra- and interobserver validity were achieved using the 3D fluoroscopy in detecting penetrating screws into the humeral head. Therefore, the use of the 3D fluoroscopy may help reducing the complication of penetrating intra-articular screws in proximal humerus fracture fixation.

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**WITHDRAWN**

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**Fluid Resuscitation Using Enteral Route Is a Safe and Effective Alternative to Parental Resuscitation in Patients Undergoing Major Elective Surgery**

*Professor Rajeshwar Srivastava, Sr.; Kavita Baghel; Saloni Raj; DEGREES???*  
*KG Medical College, Lucknow, India*

**Background/Purpose:** It has been reported that equal volumes of IV saline or plasma were often less effective than enteral administration of saline because an oral (gastric) bolus would enter the circulation over time, while an IV bolus might cause acute hemodynamic overload. Postoperative complications are quite common in patients following major surgery and thus require effective prophylaxis. In major surgical patients, we found that adequate preoperative fluid resuscitation can be successfully achieved using enteral route and fluid through enteral route may be helpful in improving the blood pressure, reducing postoperative septic complications and endotoxemia. A convenient and easy alternative to IV fluid administration is to drive fluids through the normal functioning gut. Although not common, this practice has significance in mass casualties and some elective situations. This study determines the feasibility of enteral resuscitation as an alternative to standard IV therapy in hydration of patients undergoing major surgery and its effect on endotoxemia.

**Methods:** 60 patients who underwent major surgery were randomized into three equal groups: A, B, and C. Group A received 4 L of fluid through enteral route and group B received 4 L through IV route for 48 hours. Group C received no extra fluid other than usual oral liquid diet. Vital parameters, urine output, serum bilirubin, serum creatinine, creatinine clearance rate, electrolytes, and endotoxin levels were monitored.

**Results:** Significant improvement in blood pressure was observed in groups undergoing fluid resuscitation (groups A and B). None had any evidence of renal failure prior to intervention and the renal functions remained within normal limits postintervention. The average urine output with group C was significantly less than other two groups (A and B). Febrile events and electrolyte abnormalities were found more in group B using IV route; however, this was statistically insignificant. Significant decrease was observed in endotoxin concentrations in all groups, although the decrease was maximum in enteral group A.

**Conclusion:** In major surgical patients, we found that adequate perioperative fluid resuscitation can be successfully achieved using enteral route and fluid through enteral route may be helpful in improving the blood pressure and reducing postoperative septic complications and endotoxemia.

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## Locked Minimally Invasive Plating (PCCP) Versus Fourth-Generation Nailing (Trigen Intertan Nail) in Unstable Pertrochanteric Femur Fractures: A Biomechanical Evaluation

*Matthias Knobe, MD<sup>1</sup>; Gertraud Gradl, MD<sup>2</sup>; Andreas Prescher, MD<sup>3</sup>; Richard Martin Sellei, MD<sup>1</sup>; Philipp Kobbe, MD<sup>1</sup>; Roman Pfeifer, MD<sup>1</sup>; Philipp Lichte, MD<sup>1</sup>; Hans-Christoph Pape, MD<sup>1</sup>;*

<sup>1</sup>*Department of Orthopedic and Trauma Surgery, Medical Faculty, RWTH Aachen University, Aachen, Germany;*

<sup>2</sup>*Department of Orthopaedic Surgery, Massachusetts General Hospital, Boston, Massachusetts, USA;*

<sup>3</sup>*Department of Molecular and Cellular Anatomy, Medical Faculty, RWTH Aachen University, Aachen, Germany*

**Background/Purpose:** Several meta-analyses have not been able to confirm the clinical superiority of extramedullary or intramedullary implants in pertrochanteric femur fractures. Additional studies are needed particularly for the more recently developed designs of intramedullary nails that have potentially fewer complications in comparison to those with previous nails. The Trigen Intertan Nail (Smith & Nephew) is an intramedullary system of the fourth generation with an integrated compression screw that offers rotational stability and enables linear compression. Locked minimally invasive plating (PCCP;) gives implant failure rates that are similar to those obtained with conventional sliding hip screw devices, but potentially could reduce the complication rate by a reduced incidence of medial shaft displacement and fracture collapse and by providing better lateral cortical support, which is an important predictor of reoperation. The goal of this biomechanical study was the evaluation of these newer implants in terms of stiffness and ultimate failure load, taking into account the rotational and migrational moment in unstable pertrochanteric fractures.

**Methods:** In eight paired femurs (mean age: 84 years; range, 61-100), a PCCP or Intertan Nail was implanted. An unstable pertrochanteric osteotomy was carried out using an oscillating saw at an angle of 40° to the femur axis (AO/OTA 31A2.2), with removal of the trochanter minor. Beginning with 300 N and under consecutive 300-N load increase steps (2000 cycles, 0.5 Hz), the femurs were stressed until failure. Specimens were evaluated for fragment dislocation in both frontal and rotational planes, as well as for migration (paired Wilcoxon signed-rank test). A survival analysis according to the failure limit was carried out.

**Results:** With regard to stiffness (PCCP vs Intertan: 249 ± 124 N/mm vs 273 ± 153 N/mm;  $P = 0.737$ ) and ultimate failure load (1988 ± 640 N vs 2400 ± 752 N;  $P = 0.063$ ), no statistically significant differences emerged. The Intertan Nail proved superior to PCCP with regard to the number of cycles reached before failure occurred (PCCP vs Intertan: 12,691 ± 4733 vs 15,313 ± 4875 cycles;  $P = 0.023$ ). Except for greater sintering of the PCCP at a load level of 900 N (PCCP vs Intertan: 3 vs 1 mm;  $P = 0.031$ ), no differences emerged between the intra- and extramedullary implants, even in terms of rotational stability or migrational screw behavior.

**Conclusions:** This study showed the superiority of the new Trigen Intertan Nails compared with the percutaneous compression plates (PCCP) with regard to number of cycles

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achieved under sequential load increases for unstable pertrochanteric femur fractures. Stiffness, rotational stability, and migration behavior were comparable between intra- and extramedullary implants.

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### Comparison of Different Techniques for Flexible Fixation of Open Book Type Pelvic Injuries With Two-Leg Alternate Loading: A Biomechanical Study

Fabian Stuby, MD<sup>1</sup>; Yash Agarwal, PhD<sup>2</sup>; Markus Windolf, MSc<sup>2</sup>; Thomas Shiozawa, MD<sup>3</sup>; Björn Gunnar Ochs, MD<sup>1</sup>; Christoph Gonser, MD<sup>1</sup>; Ulrich Stöckle, PhD<sup>1</sup>; Boyko Gueorguiev, PhD<sup>2</sup>;

<sup>1</sup>BGU, Eberhard Karls University, Tuebingen, Germany;

<sup>2</sup>AO Research Institute Davos, Davos, Switzerland;

<sup>3</sup>Anatomical Institute, Eberhard Karls University, Tuebingen, Germany

**Background/Purpose:** The biomechanical stability of the pelvic ring is essential for the entire musculoskeletal function. Open book injuries (OTA 61-B1.1 and 61-B1.2) are usually stabilized with plates, bridging the pubic symphysis. However, this technique regularly results in screw loosening or plate breakage with indications for implant removal. The aim of this study was to investigate whether a less rigid (ie, more flexible) fixation of the pubic symphysis leads to less implant loosening, and in addition leaves the pelvic ring anatomy in a physiologic condition similar to the intact state.

**Methods:** Six human cadaver pelvis with proximal femora and intact ligaments were used in this study. They were first tested in intact state, applying nondestructive two-leg alternate cyclic sinusoidal loading through the proximal femora, increased from 170 N to 340 N over 1000 cycles (1 Hz, increase 0.17 N/cycle). The relative movements at the pubic symphysis in all six degrees of freedom were measured and calculated in terms of translations and rotations via motion tracking. An open book injury was then simulated and stabilized with a modular LCP (locking compression plate)-based implant system, fixed with two locking screws on each symphysis side, both sides connected with a variable number of rods. The stabilization was consecutively performed with one-rod (flexible in the symphyseal transversal plane), two-rod (fixed parallel to the plain of the rods), and four-rod (rigid) configurations and tested nondestructively in a randomized sequence using the same test protocol as before. Finally, a destructive cyclic test with increasing load, starting from 340 N (1 Hz, increase 0.17 N/cycle) was performed until construct failure occurred, which was defined as at least 2 mm translation along the symphyseal transversal axis. Statistical analysis was performed with Shapiro Wilk test, paired *t* test and general linear model repeated measures using SPSS software.

**Results:** Increasing number of connecting rods generally results in decline of symphysis movements. The one-rod shear translational movement along the symphyseal vertical axis at 170 N was significantly bigger compared to the two-rod and four-rod configurations ( $P < 0.03$ ). This translation at 340 N was significantly different between all three configurations ( $P < 0.04$ ). In addition, the one-rod rotational movement about the symphyseal transversal axis at 340 N was significantly bigger compared to the two-rod and four-rod configurations ( $P < 0.04$ ). During the destructive cyclic test the rigid fixation with the four-rod configuration failed first, followed by the one-rod and two-rod configurations.

**Conclusion:** The biomechanical performance of the stabilization with the two-rod configuration was superior compared to the one-rod and four-rod constructs, considering its similarity to physiologic pubic symphysis movements, and showed the lowest implant loosening and highest stability of fixation with potential to resist more than 1.5-fold body weight until implant failure occurs.

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## Evaluation of a New Fixation Concept for Intramedullary Nailing of Proximal Humeral Fractures: A Biomechanical Study

*Boyko Gueorguiev, PhD<sup>1</sup>; Stephan Rothstock, PhD<sup>1</sup>; Markus Windolf, MSc<sup>1</sup>;  
Martin Kloub, MD<sup>2</sup>; Damiano Schiuma, MSc<sup>1</sup>; Michael Plecko<sup>3</sup>, MD;*

<sup>1</sup>AO Research Institute Davos, Davos, Switzerland;

<sup>2</sup>Hospital Ceske Budejovice, Ceske Budejovice, Czech Republic;

<sup>3</sup>University Hospital Zurich, Zurich, Switzerland

**Background/Purpose:** The osteosynthesis treatment of unstable proximal humeral fractures still remains challenging. The aim of this study was to investigate a new fixation concept for intramedullary nailing with different locking options in a three-part fracture model and prove whether its design adaptations, introducing additional two locking screw-in-screw, inserted through the head of the primary proximal screws, and one calcar screw, provide better stability, considering the peri-implant bone quality in the humeral head regions engaged by the locking screws.

**Methods:** A biomechanical testing model for three-part proximal humeral fractures, including cyclic axial loading with increasing peak load and simultaneous pulling forces at the rotator cuff was used to test 12 pairs of fresh human cadaver humeri, assigned to 4 groups and intramedullary nailed with either Targon PH (Aesculap Orthopaedics; T1) or MultiLoc PHN (Synthes; standard M1; additional two screw-in-screw M2; additional one calcar screw and two screw-in-screw M3). Bone mineral density (BMD) was evaluated in the humeral head at the exact locations along the locking screw paths via high-resolution peripheral quantitative CT using XtremeCT (Scanco Medical).

**Results:** Initial range of motion in internal-external rotation and mediolateral translation was smallest in M3 ( $1.82^\circ \pm 0.38^\circ$ ;  $0.11 \pm 0.11$  mm), biggest in T1 ( $3.63^\circ \pm 0.49^\circ$ ;  $0.51 \pm 0.17$  mm) and significantly different between these two groups ( $P = 0.02$  and  $P = 0.04$ , respectively). M3 showed minimum head migration along the nail and varus tilting after 5000 cycles ( $0.31 \pm 0.14$  mm;  $0.20^\circ \pm 0.05^\circ$ ) and 10,000 cycles ( $1.59 \pm 0.68$  mm;  $0.34^\circ \pm 0.19^\circ$ ). The head migration increased significantly between 5000 and 10,000 cycles in all study groups ( $P = 0.02$ ). The additional two locking screw-in-screw in M2 and M3 were aimed at bone volumes in the posteromedial part of the humeral head with significantly higher BMD, compared to the respective primary proximal screws, through whose heads they were inserted ( $P < 0.03$ ). M2 and M3 performed better than M1 and T1 with regard to varus collapse. The highest number of cycles to failure was observed for M3 ( $20,733 \pm 1669$ ) and the lowest for T1 ( $10,083 \pm 3939$ ) with significant difference between these two groups ( $P = 0.04$ ).

**Conclusion:** Both nail constructs performed very well biomechanically and would be a good choice for treatment of proximal humeral fractures. The locking configuration with two screw-in-screw and one calcar screw was superior in most aspects, while both options with two screw-in-screw showed better behavior with regard to varus collapse. This confirms that the additional two screw-in-screw can be used to increase osteosynthesis stability in poor bone quality.

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**Biomechanical Evaluation of Locking Plate Fixation of Proximal Humeral Fractures Augmented with Calcium Phosphate Cement**

*Gertraud Gradl, MD<sup>1</sup>; Matthias Knobe, MD<sup>1</sup>; Marcus Stoffel<sup>2</sup>; Andreas Prescher, MD<sup>3</sup>; Timm Dirrachs<sup>4</sup>; Hans-Christoph Pape, MD<sup>1</sup>;*

*<sup>1</sup>Department for Trauma Surgery, University of Aachen, Aachen, Germany;*

*<sup>2</sup>Institute of General Mechanics, University of Aachen, Aachen, Germany;*

*<sup>3</sup>Institute of Molecular and Cellular Anatomy, University of Aachen, Aachen, Germany;*

*<sup>4</sup>Department for Diagnostic and Interventional Radiology, University of Aachen, Aachen, Germany*

**Background/Purpose:** Locking plate fixation of proximal humeral fractures is associated with the risk of glenohumeral joint screw penetration. The potential beneficial effects of calcium phosphate cement augmentation on fixation stability have not been extensively studied. The study evaluates the biomechanical properties of a locking plate augmented with calcium phosphate cement. The hypothesis is that cement augmentation increases the specimens' load to failure, prevents humeral head varus displacement, and reduces the risk of glenohumeral screw penetration.

**Methods:** In 11 paired fresh-frozen human cadaver humeri (age >65 years), a 5-mm wedge osteotomy was created and specimens were randomly assigned to receive either plate fixation (Group I) or cement augmentation and plate fixation (Group II). Constructs were tested for axial stiffness, load to failure, and failure mode using a material testing machine.

**Results:** There was no significant difference in axial stiffness between groups. In Group I, varus displacement and glenohumeral screw perforation occurred in all cases. Varus displacement occurred in two cases in Group II whereas glenohumeral screw perforation did not occur in any case. Cement-augmented specimens resisted significantly higher loads ( $1936.36 \pm 608.72$  N) in comparison to nonaugmented specimens ( $1372.73 \pm 590.07$  N).

**Conclusion:** Calcium phosphate cement-augmented locking plates enhanced fixation stability in proximal humeral fractures and reduced glenohumeral screw perforation in this two-part cadaveric model. The ultimate advantage of this method will have to be determined in vivo.

### **Reaching Agreement Between Trainees and Consultants in Their Assignment of the Young and Burgess Radiographic Classifications of Pelvic Fractures in the Emergency Room**

*Thomas Kurien, MBBS, MSc, BS; D. P. Forward; D. M. Hahn; A. Fowler; M. Raglan; R. G. Pearson; C. G. Moran;*

*Division of Trauma and Accident Surgery, Nottingham University Hospital, Nottingham, England, United Kingdom*

**Background/Purpose:** Traumatic high-energy pelvic fractures are associated with significant disability and mortality, hence early diagnosis, immediate resuscitation, and communication with an experienced pelvic surgeon is essential to improve patient survival and outcome. Classification of these fractures using the Young and Burgess system, into lateral compression (LC I-III), AP compression (API-III) and vertical shear (VS) fractures is difficult, especially in the emergency room environment with poor radiographs. We assessed the use of the Young and Burgess classification for pelvic fractures among orthopaedic residents (year R1-R5) and pelvic consultants in the resuscitation room in our Level I trauma center. Interobserver reliability was conducted to determine if trainees were able to recognize life-threatening pelvic fracture subtypes using this classification.

**Methods:** 42 AP radiographs were collected randomly from our admission database and were scored using this classification. The images were blinded and randomly assembled and distributed to three orthopaedic residents (R4-R6), three orthopaedic SHOs (senior house officers; R1-R3), and three pelvic trauma consultants to assess the interobserver agreement in the classification scores. Each observer graded the radiographs independently and statistical analysis was conducted using a blinded researcher not involved in the scoring process using SPSS software. Kappa analysis for multiple observers was conducted to assess residents' correlation with the pelvic surgeons. Kappa values of 0 to 0.20 indicate a poor agreement; 0.21 to 0.40, fair agreement; 0.61 to 0.80, substantial agreement; and >0.80, almost perfect agreement.

**Results:** The overall interobserver variability between pelvic surgeons and trainees yielded an overall Kappa score of 0.224. The agreement between all three R4-R6 residents was poor with a kappa value of 0.134. The agreement between all three R1-R3 residents yielded a value of 0.235. When comparing individual trainees' agreement to the pelvic surgeons, all trainees had fair agreement, with values between 0.21 and 0.40. Comparing the three main fracture groups with no subtypes improved interobserver agreement with a value of 0.41 obtained.

**Conclusion:** This novel research is the first study comparing residents to pelvic consultants using the Young and Burgess classification to score AP pelvic radiographs in the emergency room. This result highlights the significant interobserver variation seen between residents when assessing pelvic fractures and consequently this **poor classification from resuscitation radiographs** could lead to a failure to appreciate the risk of hemorrhage and injuries to other body systems.

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### **Pelvic Fracture Classification as a Key to Transfusion Requirements**

*Nikolaos K. Kanakaris, MD; O. Obakponovwe; K. Harvey Kelly;*

*R. M. West; Peter V. Giannoudis, MD;*

*Academic Department of Trauma and Orthopaedics, Leeds Teaching Hospitals,  
School of Medicine, University of Leeds, Leeds, United Kingdom*

**Background/Purpose:** The Young-Burgess classification of pelvic fractures, dated since the 1990s, has been shown to correlate with blood transfusion, overall resuscitation requirements, and outcomes. Our purpose was to investigate whether this is still valid following the ongoing advances in trauma care (reduced rescue times, transfusion guidelines, interventional radiology, and advances in our understanding of the physiologic response to injury, general trauma management).

**Methods:** We conducted a prospective comparative analysis of blunt pelvic fractures with complete hospitalization documentation of their first 48 hours. Children, pathologic fractures, and dead-on-arrival cases were excluded. Demographics, ISS, hospital/ITU (critical care) stay, transfused blood products, and mortality were documented. Descriptive statistics were utilized as appropriate.

**Results:** 110 patients met the inclusion criteria (males 63.6%, average age 38.5 years [range, 15-90]). The average overall ISS was 21 (range, 5-45), and the average length-of-hospital-stay 23.7 days (range, 4-67). 41.8% required ITU treatment for average 6.3 days (range, 2-29). The overall mortality was 6.5%, referring to a subgroup of significantly higher ISS (average 41.6 [range, 17-66]). The average overall transfusion requirements for RBC/FFP/PLT (red blood cells/fresh-frozen plasma/platelets) were 4.5 (range, 1-23)/1.5 (range, 1-12)/1.1 (range, 1-12) units, respectively. The subgroups (Young-Burgess classification) were LC1 (lateral compression) = 38 cases (34.2%), LC2 = 6 cases (5.4%), LC3 = 2 cases (1.8%), AP1 = 2 cases (1.8%), AP2 = 29 cases (26.1%), AP3 = 10 cases (9%), VS (vertical shear) = 8 cases (7.2%), CMI (combined mechanical injury) = 4 cases (3.2%), and iliac-blade = 11 cases (9.9%). The mean ISS was higher in the CMI, VS, AP2 and AP3 groups (30.3, 20.4, 21.8 and 26.7 respectively) when compared with the rest. All these characteristics were comparable with those of the original publication of Burgess in 1990. The AP3 group had the highest average RBC transfusion rates, 7 units (range, 4-12), followed by VS injuries with 4.5 units (range, 2-8). The relative numbers of the Burgess were significantly higher (AP3 35.4 units, VS 9.4 units). The mortality was highest between the LC3 group (33.3%) differing from the study of Burgess (AP3 group [42.8%]).

**Conclusion:** The classification of Young and Burgess appears to withstand the test of time as to its correlation to the resuscitation requirements and the clinical outcome; however, substantial differences to the reported quantitative parameters were noticed.

**Long-Term Follow-up of Opioid Use in Patients With Acetabular Fractures***Karl-Åke Jansson, PhD;**Karolinska Institutet, Stockholm, Sweden*

**Background/Purpose:** Chronic pain and the pattern of opioid use after skeletal fractures has been a neglected topic in pain medicine. Pelvic and in particular acetabular fractures represent some of the most troublesome injuries for patients with a high incidence of chronic pain after fracture. We examined the long-term opioid analgesic use among patients with acetabular fractures and analyzed if potential risk factors would predict a prolonged opioid therapy.

**Methods:** Data were extracted from medical databases such as the “Blinded” National Hospital Discharge Register and the National Pharmacy Register. The study period was 2005 to 2008. Kaplan-Meier analysis constructed the cumulative opioid consumption with 95% confidence intervals (CI). Cox multiple-regression model was used to study risk factors for a prolonged opioid prescription after admission for fracture. An age- and sex-matched control group was included for comparisons.

**Results:** We identified 1017 patients with isolated acetabular fractures. The proportion of dispensing opioids for these patients was 39%, which was 7 times higher than in the age- and sex-matched nonfracture controls (n = 5077). The median follow-up time was 14 months (interquartile range [IQR], 5-24). Most patients with opioid use after fracture were male (60%) and the median age was 76 years (IQR 61-85). The leading mechanism of injury was fall on the same level (52%). At 6 and 12 months after fracture, 41% (95% CI 36-47) and 33% (28-39) were still treated with opioids. The multiple Cox regression analysis (adjusted for age, sex, type of treatment, and mechanism of injury) revealed that younger patients (age <70 compared with ≥70 years) were more likely to end using opioids (hazard ratio 2.0; 95% CI, 1.5-2.7). The median daily morphine equivalent dose was 22 mg (IQR 14-42) within the first month after fracture.

**Conclusions:** During follow-up, the frequency of patients on moderate and high doses was falling off. There was no evidence of analgesic tolerance in the majority of the patients who were treated for at least 6 months. To set our findings into perspective, studies of patterns of chronic opioid use among patients with other types of fractures would be valuable.

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### Comparison of Acetabular Fracture Reduction Quality by the Ilioinguinal or the Modified Stoppa Approaches

Nachshon Shazar, MD; Iris Eshed, MD; Nissim Ackshota, MD; Oded Hershkowitz, MD; Alexander Hazanov, MD; Amir Herman, MD, PhD;

Institution(s) \_\_\_\_\_?

**Background/Purpose:** Successful clinical outcome of acetabular fracture surgery is defined by reduction quality. The ilioinguinal approach has been the principal anterior surgical approach used by acetabular surgeons for many years. The modified Stoppa was recently proposed as an alternative anterior approach. The goal of this study is to compare the reduction quality, surgery time, and early postoperative complications between the two surgical approaches.

**Methods:** Clinical files and radiographic examinations of 122 patients operated in our center between 1996 and 2003 with the ilioinguinal approach and 103 cases operated between 2004 and 2011 with the modified Stoppa approach were retrospectively reviewed. The patients' demographics, fracture type, fracture reduction quality, surgery time, and postoperative complications were evaluated.

**Results:** Fracture type distribution was similar for both surgical approaches. Anatomic reduction was achieved in 84 patients (68.9%) treated by the ilioinguinal approach and in 85 patients (82.5%) treated by the modified Stoppa approach ( $P = 0.018$ ). There was a significant difference in the both-column acetabular fracture type in which anatomic reduction was achieved in 54.2% of the ilioinguinal group and 79.4% of the modified Stoppa group ( $P = 0.018$ ). Mean surgery time for the ilioinguinal and modified Stoppa approaches were 293 minutes (standard deviation [SD] 92.1) and 240.5 minutes (SD 67.2), respectively ( $P = 0.001$ ). In the ilioinguinal group, surgery time decreased as the number of surgeries increased ( $P = 0.021$ ); a similar trend was not found in the modified Stoppa group. Complication rates were similar for both groups.

**Conclusions:** The modified Stoppa approach is a safe alternative that in our hands offers better exposure and improved reduction quality of acetabular fracture compared to the ilioinguinal approach. The major advantage of the modified Stoppa approach is that it enables reduction of the posterior column and the quadrilateral plate from the contralateral side by applying a buttress plate below the pelvic brim.



**Long-Term Outcome and Quality of Life of Patients With Unstable Pelvic Fracture Treated by Internal-External Fixator**

Gary Chen, MD<sup>1</sup>; Guo Fu, MD, PhD<sup>2</sup>;

<sup>1</sup>California Hospital Medical Center, Los Angeles, California, USA;

<sup>2</sup>The First Affiliated Hospital of Sun Yat-Sen University, Guangzhou, Guangdong Province, China

**Purpose:** Internal-external fixator (IEF) is a biomechanically sound construct for unstable pelvic fracture. It is based on external fixation technology but sits under the skin, which is minimally invasive and able to avoid the risk of pin-tract infection. The aim of this study was to evaluate the long-term outcome of IEF treatment in patients with unstable pelvic fractures.

**Methods:** 24 patients (11 females, 13 males; mean age 38 years; range, 19-82 years) who had unstable pelvic fractures and were treated with IEF were enrolled in the study. Short Form-36 (SF-36) scores, Majeed scores, Iowa Pelvic Scores, and Pelvic Outcome Scores were determined for the outcome assessment.

**Results:** The range of follow-up was 6 to 43 months. The mean ISS was 39 (range,31-50). The average SF-36 scores were comparable with the general population in terms of bodily pain, general health, and social function. The mean Majeed functional pelvic score was 55 (range, 34-67) and the mean Iowa Pelvic Score was 54.2 (range, 28-67).

**Conclusion:** We have demonstrated better outcomes in patients with pelvic fractures treated with IEF. The technique may be advantageous as it is minimally invasive and avoids the use of extensive approaches, risk of pin-tract infection, and prolonged surgeries.

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**Early Experiences With a Pelvic Reduction Frame to Provide Intraoperative Femoral Head Positioning During Fixation of Difficult Acetabular Fractures**

*Edward Britton, MB, BS; J. Stammers; P. Culpan; P. Bates;  
Barts and the London Hospitals Pelvic Unit, United Kingdom*

**Background/Purpose:** Certain acetabular fractures involve impaction of the weight-bearing dome and medialization of the femoral head. Intraoperative fracture reduction is made easier by traction on the limb, ideally in line with the femoral neck (lateral traction). However, holding this lateral traction throughout surgery is very difficult for a tiring assistant. We detail a previously undescribed technique of providing intraoperative lateral femoral head traction via a pelvic reduction frame, to aid fixation of difficult acetabular fractures.

**Methods:** The first 11 consecutive cases are reviewed (Group 1) and compared with a retrospective control (Group 2, n = 22) of case-matched patients, treated prior to introducing the technique. The postoperative radiographs and CT scans were assessed to identify quality of fracture reduction according to the criteria of Tornetta and Matta. Operative time, blood loss, and early complication rates were also compared.

**Results:** All cases in both groups were acute injuries with medial and/or superior migration of the femoral head. The majority were either associated both-column or anterior column posterior hemitransverse. There was no statistical difference between the groups in age, time to surgery, body mass index, or American Society of Anesthesiologists grade. Fracture reduction was assessed as excellent in seven, good in three, and poor in one. This was not significantly different from the control group ( $P = 0.3$ ). The mean operative time was 193 minutes in Group 1 and 255 minutes in Group 2 ( $P = 0.04$ ). There was no difference between the groups for blood loss or complication rates.

**Conclusions:** For certain difficult acetabular fractures, the results of this new technique were at least equivalent to using manual traction. The technique may reduce surgical time.

### **Correction and Lengthening of Posttraumatic Lower Extremity Deformities Using Intramedullary Lengthening Devices**

*Metin Kucukkaya, MD; Ozgur Karakoyun, MD; Sami Sokucu, MD; Ramazan Soydan, MD; Istanbul Bilim University Medical Faculty, Department of Orthopaedics & Traumatology, Istanbul, Turkey*

**Purpose:** The aim of this study was to evaluate the effectiveness of intramedullary lengthening devices in correction and lengthening of posttraumatic lower extremity deformities.

**Methods:** 14 patients (14 femurs) were treated with intramedullary lengthening devices (7 FITBONE [Wittenstein, Igersheim, Germany], 6 ISKD [Orthofix, McKinney, TX], and 1 PRECICE [Ellipse Technologies, Irvine, CA]) to treat posttraumatic deformity and limb-length discrepancy (LLD). The mean age of the patients was 26.8 years (range, 14-41). The etiologies of the malunion and LLD were fall from height and gunshot injury. The preoperative LLD was 6.2 cm (range, 3.5-10). Acute deformity correction and simultaneous lengthening were performed in six cases. In one ipsilateral distal femoral nonunion and LLD case, treatment of the nonunion and ISKD application was performed at the same operation. Another LLD case with ipsilateral femur and tibia deformity was treated with femoral FITBONE and tibial plate at the same operation.

**Results:** The mean lengthening was 5.5 cm (range, 3.5-8). The time to full weight bearing was 5.2 months (range, 5-7). The healing index was 1.1 month/cm. One nail was broken during the consolidation period and replaced with a standard nail. Solid consolidation was obtained in all cases. Uncontrolled distraction (one case) and early consolidation (one case) were observed. The preoperative range of motion was reobtained in all cases. Scar formation was minimal and all patients approved the cosmetic result. There was no infection in any of our cases.

**Conclusions:** The intramedullary lengthening devices have clear advantages for acute deformity correction and lower limb lengthening in posttraumatic malunion and LLD. Rehabilitation and pain management are easy. The scar tissue formation is low, and patient compliance is high. Most of the complications caused from excessive reaming, uncontrolled distraction, and implant failure.

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## Functional Outcome Following Floating Knee Injuries Treated by Different Surgical Methods

*Rajeev Kumar, MS, MBBS;*

*Sant Ishar Singh Hospital, Pehowa*

**Background/Purpose:** Floating knee injuries cause significant morbidity despite advances in surgery. This study was undertaken due to increasing incidence of road traffic accidents and concomitant floating knee injuries. The aims of the study were to evaluate the functional recovery of the patients as compared to preinjury status using Karlström and Olerud criteria, to study the incidence of concomitant fracture of ipsilateral femur and tibia, to study the various modalities of surgical management of floating knee injuries, to study the various factors affecting the functional prognosis of floating knee, and to study the various complications associated with floating knee injuries.

**Methods:** This prospective study was done from June 2006 to January 2009 after approval from the ethical committee of our hospital and comprised of 30 patients with 30 floating knee injuries. Patients having ipsilateral fracture shaft femur and tibia (ie, McBryde and Black Type I) and also ipsilateral fracture femur and tibia with extension into knee joint (ie, McBryde and Blake Type IIA) were included in this study. Pure epiphyseal or epiphyseometaphyseal fractures without metaphyseodiaphyseal disassociations and deaths were excluded from the study. Patients who were lost to follow-up or follow-up of less than 5 months were also excluded from the study.

**Results:** The majority of patients were male from 19 to 29 years of age involving the right side following high-velocity road traffic accidents. Two cases of femur showed delayed union. Three cases of tibia showed delayed union and two tibial fractures went into nonunion. There was local infection in 4 cases of tibial fractures out of 30 and there was no infection associated with femoral fractures. 70% of patients achieved excellent to acceptable knee range of motion (ie, 100°). Knee stiffness (ie, loss of knee flexion more than 30°) developed in 7 cases (58%) out of the total 12 McBryde and Blake Type IIA floating knee cases, whereas 11% (2 patients out of 18) of McBryde and Blake Type I floating knee developed knee stiffness. By using Karlström and Olerud criteria the functional outcome in our study was excellent in 13 patients (43%); good in 8 patients (27%); acceptable in 4 (13%), and poor in 5 (17%).

**Conclusion:** In this study of 30 cases with 30 floating knee injuries we conclude that concomitant fracture of ipsilateral femur and tibia entails a considerable risk of complications and permanent disability. High-energy mechanism, extensive soft-tissue trauma, and other associated injuries make the treatment of patients with floating knee injury a challenging problem. Aggressive internal fixation, if done with correct surgical technique, permits early mobilization of patients with ipsilateral fractures of femur and tibia and considerably shortens the period of hospitalization and occupational disability.

**Open Reduction of Chronic Shoulder Dislocations by an Extensile Approach, Circumferential Capsulotomy, and Mobilization of Rotator Cuff Muscles**

*Duane Anderson, MD<sup>1</sup>; Lucas Anderson, MD<sup>2</sup>; Stephen Aoki, MD<sup>2</sup>; Segni Bekele, MD<sup>1</sup>; Abebe Chala, PT<sup>1</sup>;*

*<sup>1</sup>Soddo Christian Hospital (SCH), Soddo Wolaitta, Ethiopia;*

*<sup>2</sup>University of Utah Department of Orthopedics, Salt Lake City, Utah, USA*

**Purpose:** There is little written in the international orthopaedic literature about open reduction of chronic shoulder dislocation. In the developed world it is uncommonly treated and in the developing world there has been insufficient interest in the topic because of historical poor results with operative treatment with limited treatment options. Over the last several years we have developed an operation that we believe will bring hope for surgeons who face this problem.

**Methods:** All patients with chronic anterior dislocation of the shoulder were found by medical records review at SCH. Patients with posterior dislocations, fracture-dislocations were not included. 10 patients were found and 8 returned for clinical follow-up. These 8 are the subject of this study. The patients were examined by a physical therapist and range of motion and strength and oral surveys taken (multiple language groups). Patients had surgery from 6 weeks to 1 year postinjury. The operative procedure included a takedown of the anterior deltoid to the lateral acromium, coracoid osteotomy, subscapularis reflection, circumferential capsulotomy, biceps tenotomy, mobilization of the posterior rotator cuff from the scapula by subperiosteal dissection, and stretching of the posterior cuff. Usually no pinning of the head was performed. The operative procedure on a cadaver is part of the presentation.

**Results:** Constant scores were from 53 to 100. Two patients had reoperations for subluxation or dislocation on postoperative radiographs. There were no infections or nerve injuries. Stiffness was the most common complication. The patient with a Constant score of 100 had surgery 1 year after injury. He is the only patient who returned for organized physical therapy (PT).

**Conclusions:** It is possible to reduce chronic shoulder dislocations without head collapse in a limited resource setting. A stepwise operation that preserves the integrity of the head and allows complete reduction of the head into the glenoid can be done. Stiffness is the biggest challenge in our setting and an organized PT program can give excellent results. A well devised operation and PT are both needed for an excellent result.

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## Social Deprivation Influences the Epidemiology and Outcome of Proximal Humeral Fractures in Adults

Nicholas David Clement, MBBS; Margaret M. McQueen, MD;

Charles M. Court-Brown, MD;

Orthopaedic Trauma Unit, Royal Infirmary Edinburgh, Edinburgh, Scotland, United Kingdom

**Purpose:** The primary aim of this study was to describe the epidemiology and incidence of proximal humeral fractures over a 17-year period in relation to the socioeconomic status of the patient. Our secondary aim was to investigate whether the socioeconomic status of the patient influenced functional outcome after a proximal humeral fracture.

**Methods:** Over a 17-year period three prospective databases were compiled, which recorded patient demographics, socioeconomic status, and fracture severity for consecutive proximal humeral fractures presenting to the study center. There were 1880 fractures in 1848 patients available for analysis from the 1992 to 1996 ( $n = 1027$ ), 2000 ( $n = 337$ ), and 2008 ( $n = 516$ ) databases. Demographic details of domicile and independence were available from the databases. The Carstairs score was used to assign the socioeconomic status of each patient. The AO and Neer classification was used to assess fracture severity. 776 patients had functional scores available 1 year postinjury. Operative management was undertaken in 65 patients, with the remainder ( $n = 711$ ) being managed by nonoperative methods.

**Results:** The incidence of proximal humeral fractures significantly increased during the study period from 47.9/10<sup>5</sup>/year to 64.3/10<sup>5</sup>/year in 2000 ( $P = 0.002$ ), and to 98.7/10<sup>5</sup>/year in 2008 ( $P < 0.0001$ ). This significant increase in incidence was observed for all social quintiles, but was significantly ( $P < 0.001$ ) greater for the most deprived patients. There was a significantly greater incidence for the most deprived patients ( $P < 0.0001$ ). There were no significant differences in age or gender between social quintiles. There was, however, a trend towards younger age with more deprived social quintile ( $P = 0.026$ ). Social quintile had no significant affect upon fracture severity according to Neer and AO classifications. The Constant score at 1 year was 68.5 (range, 11-100; standard deviation, 16.8) for all patients. Univariable analysis identified that female gender, older age, residence within an institution, social dependence, fracture severity, and operative management were all associated with a worse 1-year Constant score. These predictors were entered into the multivariable model with social quintile, all of which were demonstrated to be significant ( $P < 0.05$ ) isolated independent predictors of 1-year Constant score ( $r^2 = 0.51$ ).

**Conclusion:** This study has demonstrated that the incidence of proximal humeral fractures has increased during the last 2 decades, which was greatest for the most socially deprived reaching 274/10<sup>5</sup>/year. Hence, socially deprived patients were at an increased risk of sustaining a proximal humeral fracture, and sustained their injury at a significantly younger age when compared to more affluent patients. Social deprivation was also an independent predictor, after adjusting for other confounding variables, of a significantly worse functional outcome according to their Constant score at 1 year.

**Treatment of Bone Defects in Children Caused by Chronic Hematogenous Osteomyelitis: A Retrospective Review of 57 Patients**

*Andrew J. Stevenson, MD; M. Stolbrink; D. Moffatt; W. J. Harrison; J. Cashman;*  
*FULL NAMES and DEGREES???*

*Beit CURE International Hospital, Blantyre, Malawi*

**Purpose:** We present our experience of treating 57 cases of bone defects associated with chronic osteomyelitis (COM) and a new algorithm for their treatment.

**Methods:** A retrospective analysis of our operation database revealed 377 patients treated for COM (2002–2010). 76 (20%) had bone defects; of these, 57 had notes and radiographs available. Bone defects were defined as a loss of bony continuity and ranged from pathologic fracture to large segmental defects. Data were collected on age, sex, type/extent of bone involved, number/type of procedures, and length of stay. The tibia was most commonly affected (63%), followed by the femur (21%). Infection control procedures included débridement, drilling, and sequestrectomy. Fully healed skin, absence of sequestrae on radiographs, and no antibiotics for 2 months were prerequisites prior to reconstruction surgery. Decision on the method of treatment of defect was made depending on age, size of defect, viability of periosteum and physes, condition of soft tissues, and coexisting deformity. Our aim was to use the simplest reconstruction method we felt would give a good chance of success.

**Results:** Initial treatment was; plaster stabilization (15), frame stabilization (6), free fibula structural bone grafts (9), ipsilateral vascularized fibula graft (7), nonstructural cancellous bone graft (8), bone transport (8), and amputation (4). 43 patients (75%) were successfully treated with initial strategy. Initial treatment therefore failed in 14 patients (25%). Successful treatment subsequently used was structural bone grafting (6), nonstructural bone grafting (4), bone transport (3), and stabilization with Rush rod (1).

**Conclusions:** Little is known about osteomyelitis-induced bone defects, which cause massive morbidity in developing countries. Our novel research shows that these can be treated successfully, often by relatively simple methods. In the absence of ongoing infection, non-vascularized bone grafting techniques are often successful. Bone transport or vascularized grafting are more reliable but more complex solutions.

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**Intra-Articular Fractures of the Calcaneus in Childhood**

Marcel Dudda, MD; C. Kruppa; J. Geßmann; D. Seybold; T. A. Schildhauer;

*FULL NAMES and DEGREES???*

University Hospital Bergmannsheil, Ruhr University of Bochum, Bochum, Germany

**Background/Purpose:** Calcaneal fractures in childhood are very rare, whereas particularly intra-articular displaced fractures are atypical for skeletally immature children. Various techniques of osteosynthesis and treatment are possible and discussed in literature. The purpose of the study was to determine the outcome after operative treatment with regard to the clinical and radiological results.

**Methods:** From 2000 to 2008, 15 intra-articular fractures of the calcaneus were included. 11 children from 6 to 17 years of age (mean 11.5 years, 2 girls/9 boys) were treated operatively. One child sustained an open fracture of both heel bones. All injuries occurred in consequence of high-energy trauma; in three cases patients had multiple additional fractures after a fall from a significant height. With regard to the classification of Essex-Lopresti, 12 patients had a joint-depression-type injury, 3 fractures were a tongue-type. The clinical and radiologic follow-up was on average 41 month postoperatively.

**Results:** Depending on the soft-tissue condition, operation was performed after 6 days. In four cases a reduction through a minimally invasive approach and fixation with Kirschner wires (K-wires) or screws could be achieved. In 11 patients an open reduction and internal fixation with plate osteosynthesis, K-wires, or screws was implemented. In the case with open fractures of both heel bones, an additional external fixator was applied. Postoperative complications like infections or wound healing disorders were not observed. Due to the operative treatment the preoperative average measured angle of Böhler of 16° could be improved to an average 30°. With the exception of the patient with open fractures, in all cases a good functional and pedobarographic result could be achieved.

**Conclusion:** In calcaneal fractures in childhood, the anatomic reduction is the most determining fact as in fractures in the adult, whereas the operative technique seems to have no influence to the clinical outcome in children. The often-described wound healing problems were not observed in this age group.



**The Gamma3 International Multicenter Prospective Clinical Follow-up Evaluation***E. Wilde<sup>1</sup>; Arndt P. Schulz, MD, PhD<sup>1,2</sup>; N. Reimers<sup>3</sup>; C. Beigel<sup>3</sup>; Ch. Jürgens<sup>1,2</sup>***FULL NAMES and DEGREES???**<sup>1</sup>*University Hospital Lübeck, Lübeck, Germany;*<sup>2</sup>*BG Trauma Hospital Hamburg, Hamburg, Germany;*<sup>3</sup>*Stryker Trauma, Schönkirchen, Germany*

**Background/Purpose:** The well-known gamma nailing system was significantly modified and the new version has been introduced to the market in 2004 under the name Gamma3. Actual literature research offers no relevant studies evaluating the modification effects. Therefore the Gamma3 international multicenter clinical investigation was designed to focus on management options for intertrochanteric fractures of the hip and started in the first site in 2006. This study was sponsor-initiated (Stryker). The actual presented data of 347 patients were collected on 26 April 2011. Aim of this presentation is to present the study design in detail and to demonstrate early results of the study.

**Methods:** The study was designed as a Europe-wide multicenter prospective clinical investigation with a 4/12/24-month follow-up period with the results regarding functional outcome, technical safety, and complications of the intramedullary nailing device system Gamma3. This study follows the guidelines of the "Declaration of Helsinki" including all amendments and the rules of "Good Clinical Practice". Ethical approval was obtained for all investigational sites. Data management was performed by an Internet-based electronic case report form (eCRF) and validated according to the GAMP Guidelines. Results obtained from the clinical investigation were statistically analyzed using SPSS software. A contract research organization was used for monitoring of data quality. Inclusion criteria were besides age >50 years, the ability to give informed consent and the patient's ability to walk prior to the accident ( $\pm$  walking aids). The data recorded included different scoring systems as the Parker mobility score, Zuckerman score, Sahlgrenska mobility score, and a modified Merle d'Aubigné score (mMDA, maximum 12 points). Additionally, relevant clinical data were collected. The follow-up examinations were performed after 4 and 12 months comprising clinical examination. At the time of data freeze in April 2011, 347 consecutive patients were included with a maximum follow-up of 12 months. This patient collective consisted of 72% female and 28% male patients. In median, they were 83 years of age (range, 50-98 years). The injuries happened in 73% at home. 196 patients (55.7%) were admitted from their own homes to the hospital. The median weight of all patients was 65.0 kg. The median body mass index (n = 340) was found to be 23.73 kg/m<sup>2</sup>.

**Results:** We found 56.9% multifragmentary pertrochanteric fractures (31-A2.1-3), 34.8% simple pertrochanteric (31-A1.1-3), and 8.2% intertrochanteric fractures (31-A3.1-3). The American Society of Anesthesiologists (ASA) classification showed the majority of patients in moderate overall condition (ASA 3; 31.2%). Half of all nails implanted featured a CCD (caput-collum-diaphyseal) angle of 125° and in 81.5% standard nails with a length of 180 mm was used followed by 320 mm (7.1%). We found nine cases of lag screw cut-out (2.6%), four cases of broken implant (1.2%), as well as two cases of subsequent femur fracture (0.6%). Activities of daily living (ADL) scores were significantly lower than preinjury level at 4 and

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12 months and increased up to the preoperative level at 24 months ( $P = 0.212$ ). The mean mMDA was determined preoperatively with 9.8 points, at 4 months with 7.6 points, at 12 months with 8.7, and at 24 months with 8.5 points.

**Conclusion:** The Gamma3 study presented has a clear and concise study design and will give a realistic insight into results achieved with the Gamma3 implant system. Early results indicate an improvement in implant-related complications compared to the old nail system. Outcomes regarding social status and mobility are satisfactory. Hip function as assessed by an abbreviated Merle d'Aubigné score remains disturbed even after 24 months.

### Multiple Fractures in the Elderly

*Nicholas D. Clement, MBBS; Stuart A. Aitken, Andrew D. Duckworth, MBChB, BSc (Hons); Margaret M. McQueen, MD; Charles M. Court-Brown, MD; Orthopaedic Trauma Unit, Royal Infirmary Edinburgh, Edinburgh, Scotland, United Kingdom*

**Purpose:** Our primary aim was to assess the prevalence of multiple fractures in the elderly, and describe the mechanisms of injury, common patterns of occurrence, the effect of socioeconomic status, and the associated standardized mortality rate. Our secondary aim was to evaluate the rate of admission and return to domicile.

**Methods:** All patients presenting to the study center with fracture(s) during a 1-year period were prospectively documented. All patients aged 65 years or more were analyzed, recording their gender, age, socioeconomic status (Carstairs score), mode of injury, number of fractures, and the fracture type. The rate of hospital admission, operative fixation, length of stay, and place of discharge were obtained for patients sustaining double fracture combinations. The standardized mortality rate (SMR), 1 year from time of injury, was calculated using data obtained from the General Registrar Office of Scotland.

**Results:** During the study period 2335 patients, aged at least 65 years, presented with 2465 fractures. 119 patients (5.1%) presented with multiple fractures. The gender ratio was 22/78 male/female and the average age was 78.7 years. Females were significantly older than males ( $P = 0.003$ ). Distal radial, proximal humeral, and pelvic fractures were associated with an increased risk of sustaining associated fractures ( $P < 0.05$ ). The rate of admission was greater than 80%. The rate of return to original place of domicile was less than 30%. The 1-year SMR for common single and multiple fractures are demonstrated in the table.

Fracture	Single Fracture	P Value	Elderly ( $\geq 65$ y) Multiple Fractures					
			All	P Value	<80 y	P Value	$\geq 80$ y	P Value
Ankle	1.85	0.02	1.95	0.32	2.66	0.31	-	-
Distal radius	0.75	0.13	1.43	0.15	2.18	0.31	1.07	1
Pelvis	2.28	<0.001	10.50	<0.001	11.64	0.03	3.45	0.003
Proximal femur	3.41	<0.001	4.66	<0.001	8.39	<0.001	3.53	<0.001
Proximal humerus	2.06	<0.001	4.95	<0.001	6.64	<0.001	4.34	<0.001

**Conclusion:** The majority of multiple fractures in the elderly occur after low-energy trauma and are predominantly of a female gender. The distal radius, proximal humerus, and pelvic fractures were associated with an increased risk of sustaining multiple fractures. Most patients required admission, despite a large proportion not needing surgical fixation and more than half needed an increased level of care before discharge. There was a significantly increased SMR associated with multiple fractures; however, this increased mortality risk diminished with increasing age, with very elderly patients having a lower risk.

- The FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an "off label" use). For full information, refer to page 619.

**Ilizarov Use in Cambodia: Indications and Complications Compared With the Western World**

*Rupert Wharton, Bm, BSc; Suzanne Zeidler; Jim Gollogly; Keith Willett, MD; James Aird; Children's Surgical Centre, Kien Khleang National Rehabilitation Center, Phnom Penh, Cambodia*

**Purpose:** Our objective is to demonstrate the versatility of Ilizarov apparatus in the developing world setting and recommend its use to other similar centers.

**Methods:** We present a review of our use of the Ilizarov apparatus in a nonacute NGO (nongovernmental organization) hospital in Cambodia specializing in limb reconstruction. Frames are applied without on-table image intensification. A retrospective case-note analysis of Ilizarov apparatus use for all indications was conducted. 53 frames were applied between November 2005 and October 2011. Indications for application were chronic open fracture, osteomyelitis, fracture malunion, infective and noninfective nonunion, bone lengthening, primary bone tumor, ankle fusion, congenital deformity or pseudarthrosis, chronic hip dislocation, or a combination of the above.

**Results:** Mean delay in presentation was 46 months for all indications (range, 1-216 months). Mean treatment length was 25.6 weeks (range, 3-76 weeks). The most frequent complication was pin-site infection. This occurred in 18 patients (34%). Unplanned return to operating theater occurred in 21 patients (40%). Indications were frame adjustment, pin addition or removal, addition of bone graft, or reosteotomy. Failure of union occurred in three patients. These rates are comparable with those published in both Asian and Western literature.

**Conclusions:** Our data demonstrate the versatility of the Ilizarov apparatus and its importance in limb reconstruction in a developing world setting. Our center relies on it as a cost-effective tool for traditional and novel indications. In our center the apparatus is applied without radiographic control and is maintained without a dedicated pin-site care program. Despite this our complication rates are comparable with Western literature. We therefore recommend it as a safe and cost-effective tool for use in other developing world settings.

## Revision With Plates in Humerus Nonunions Secondary to Failed Intramedullary Nails

Christian Allende, MD; Martin M. Mangupli, MD;

Institution(s) \_\_\_\_\_?

**Background/Purpose:** The amount of bone loss associated to loose humeral nails, the distraction and rotation forces that the humerus resists, the morbidity associated with the insertion site of intramedullary nails, and the low index of good results reported by exchange nailing in humerus nonunions differentiate this pathology from similar cases in the lower extremity.

**Methods:** We retrospectively evaluated 29 patients with humerus nonunion secondary to failed intramedullary nailing, treated by open reduction and internal fixation with plates, between 1998 and 2010. 11 had locked static nails, 10 had expansive locking systems, and 8 had elastic nails (1 to 3), in three cases associated with cerclage wire. Nonunions were metaphyseal in 12 cases and diaphyseal in 17 cases. 19 nails were placed antegrade and 10 retrograde. Time between trauma and definitive surgery averaged 13 months. Preoperative Constant score averaged 48 points (range, 12-92). Three had active infection and two had radial nerve neurapraxia.

**Results:** Nonunions were stabilized using a 4.5-mm LC-DCP (limited contact dynamic compression plate) in nine cases, with a 4.5-mm LCP (locking compression plate) in eight cases, with two plates in six cases, and with a locked 90° blade plate in six cases. In one infected case, a two stage reconstruction was performed. In six cases, the nail was not removed (in two MIPPO [minimally invasive percutaneous plate osteosynthesis] was performed). Autogenous bone graft was added in 21 cases and morcellized cryopreserved allograft in two cases. Follow-up averaged 27 months (range, 12-65). Union was achieved in all cases. Disabilities of the Arm, Shoulder and Hand (DASH) score averaged 14 points (range, 0-33). Constant score averaged 82 points (range, 56-100). Four patients had some degree of elbow extension loss (average, 20°).

**Conclusions:** Revision with plates allowed achieving good predictable results with a high union rate. Final functional limitations were secondary to preexisting lesions. Bone graft might not be necessary in nonunions in which the nail is not removed and good bone contact is possible.

- The FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use). For full information, refer to page 619.

### Multiple Trauma in Children: Prognostic Value of IL-6 for Development of Posttraumatic Complications

Frank Hildebrand, MD<sup>1</sup>; H. Andruszkow<sup>1</sup>; J. Fischer<sup>1</sup>; C. Krettek<sup>1</sup>; M. Frink<sup>2</sup>;

*FULL NAMES and DEGREES???*

<sup>1</sup>Trauma Department, Hannover Medical School, Hannover, Germany;

<sup>2</sup>Trauma Department, Hand and Reconstructive Surgery Unit, University of Marburg, Marburg, Germany

**Background/Purpose:** Multiple organ dysfunction syndrome (MODS) represents a significant reason for late mortality after multiple trauma. In adults, interleukin-6 (IL-6) has been demonstrated to be an early prognostic parameter for the development of posttraumatic MODS. However, little is known about the prognostic value of IL-6 for the development of posttraumatic complications in children with multiple trauma.

**Methods:** This prospective study included patients with an age <16 years. Further inclusion criteria were an ISS >9 and admission within 6 hours after trauma. Besides demographic data and the clinical course, overall injury severity (ISS) and injury distribution (Abbreviated Injury Scale [AIS]) were documented. MODS development was assessed by the Marshall score. Furthermore, IL-6 plasma concentrations were determined daily for a period of 14 days. The first blood sample was taken within the first 45 minutes after admission, but always before the first surgical intervention.

**Results:** 59 patients with a mean age of  $8.5 \pm 4.5$  years and an initial Glasgow coma scale of  $10.0 \pm 5.3$  were included (male:female, 52:7). Overall mortality was 3.4%. 11.9% of patients developed MODS. In these patients mortality was 28.5%. Patients with MODS had an increased duration of mechanical ventilation (MODS:  $200.9 \pm 137.1$  hours vs no MODS:  $99.7 \pm 133.5$  hours;  $P = 0.112$ ) and a longer treatment on ICU (MODS:  $13.4 \pm 6.2$  days vs no MODS:  $7.9 \pm 8.3$  days;  $P = 0.153$ ). Gender, injury distribution, and overall injury severity were not associated with MODS development. Multiple trauma patients with MODS development had significantly higher systemic IL-6 levels at day 1 and day 2 after trauma.

**Conclusion:** Gender distribution of infantile multiple trauma patients is comparable to the distribution observed in adults. Injury severity and distribution do not seem to be associated with MODS development. IL-6 seems to be a possible predictive marker for identification of patients at risk for posttraumatic MODS development. Therefore IL-6 might help to guide the surgical and intensive care therapy of infantile trauma patients.

## Is Multidetector Helical CT (MDCT) More Reliable in Diagnosing Bone Consolidation as Compared to Conventional Radiographs?

V.A.B. Scholtes<sup>1</sup>; M. Maas<sup>2</sup>; P. Karanicolas<sup>2</sup>; Mohit Bhandari, MD, PhD, FRCSC<sup>3</sup>;

*FULL NAMES and DEGREES???*

**Rudolf W. Poolman, MD, PhD<sup>1</sup>**; P. Kloen<sup>2</sup>; on behalf of the COAST

(Collaboration for Outcomes Assessment in Surgical Trials) Research Group;

<sup>1</sup>OLVG (Onze Lieve Vrouwe Gasthuis), Amsterdam, the Netherlands;

<sup>2</sup>Academic Medical Centre, Amsterdam, the Netherlands;

<sup>3</sup>McMaster University, Hamilton, Ontario, Canada

**Purpose:** Pseudarthrosis is usually diagnosed using conventional radiographs. A possible superior method is using CT. The aim of this study was to evaluate the interobserver reliability in diagnosing bone consolidation in nonunions using (1) conventional radiographs and (2) multidetector helical CT imaging using multiplanar reconstruction (MDCT/MPR). Our hypothesis is that MDCT/MPR has a higher interobserver reliability than conventional radiography.

**Methods:** This retrospective case series included 50 patients from the Academic Medical Centre in Amsterdam. Inclusion criteria were: (1) fracture of long bones and/or the axial skeleton; (2) all types of fixation; (3) complicated fracture healing as seen on radiograph (delayed or non-union); and (4) availability of MDCT. Observers were 20 international orthopaedic surgeons. All are participants of the COAST (Collaboration for Outcomes Assessment in Surgical Trials) research group. To rate the images, each logged in on the COAST web site in two separate sessions: (1) radiographs; and (2) MDCTs. Each modality (radiographs/MDCT) was scored on 4 different categories ("healed," "bridging callus," "persistence of the fracture line," "surgery advised"). Scoring options were rated on a 5-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = undecided; 4 = agree; 5 = strongly agree). Intraclass correlation coefficients were calculated using SPSS.

**Results:** 32 out of 50 patients turned out to be evaluable. Interobserver reliability of the 4 different categories was very poor for both diagnostic tools (conventional radiograph: 0.493 [95% confidence interval (CI) 0.370-0.643]; MDCT/MDR 0.455 [95% CI: 0.370-0.643]). In this study we found that the interobserver reliability of MDCT was comparably low as interobserver reliability of conventional radiographs.

**Conclusions:** The interobserver reliability in diagnosing bone consolidation in nonunions using conventional radiographs is poor, and there is no additional value of using MDCT in terms of increased interobserver reliability. Future research should aim at the development of reliable methods to determine union. International collaboration is simple using a web-based database.

- The FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an "off label" use). For full information, refer to page 619.

## The Role of the Pediatric Orthopaedic Surgeon in the Early Response to a Major Natural Disaster: A Prospective Case Study

Axel Gamulin, MD<sup>1</sup>; J. Armenter Duran<sup>1</sup>; M. Assal<sup>1</sup>; O. Hagon<sup>2</sup>; R. Dayer<sup>3</sup>;

*FULL NAMES and DEGREES???*

<sup>1</sup>Division of Orthopaedics and Trauma Surgery, University Hospitals of Geneva, Geneva, Switzerland;

<sup>2</sup>Humanitarian Aid, Swiss Agency for Development and Cooperation, Bern, Switzerland;

<sup>3</sup>Division of Orthopaedic Pediatrics, University Hospitals of Geneva, Geneva, Switzerland

**Background/Purpose:** Major natural disasters such as earthquakes may provoke a mass casualty situation. Children tend to represent an important proportion of the victims. Published guidelines on war and armed conflict surgery emphasize the leading role of experienced general surgeons in situations with new injured victims every day over a long period of time. However, natural disasters are unpredictable. External medical aid reaches the mass casualty area at least 2 or 3 days after the event, well beyond the “golden hour of trauma” during which life-threatening, heavily polytraumatized patients should receive medical support to have a chance of survival. Unstable abdominal, thoracic, neurosurgical, or pelvic trauma patients are usually already dead before the arrival of external medical aid. Surviving patients have less life-threatening injuries, such as extremity crush injuries, extremity and axial (head, spinal and pelvic) closed or open fractures and wounds, compartment syndromes, and musculoskeletal infections, which may rather belong to the field of orthopaedic surgery. Long-term disability associated with these complex injuries in growing patients would be potentially minimized with an appropriate specialized medical team. The purpose of this study was to prospectively record medical conditions presented by pediatric survivors of a major natural disaster to determine the type of medical specialists most needed during the acute phase of relief response.

**Methods:** Following the 2010 Haiti earthquake, age, sex, date of presentation, diagnosis, and treatment provided were prospectively recorded for all patients younger than 18 years of age treated by a medical relief team. Patients were then allocated to one of two groups: surgical (traumatism or surgical disorder) and medical (medical disorder). Medical activity lasted for 43 days.

**Results:** 471 patients less than 18 years old were treated during 43 days. 244 (52%) were assigned to the surgical group and 227 (48%) to the medical group. As there was a substantial decrease in the number of new surgical patients registered on day 11 of activity, an early period (until day 10 of activity) and a late period (beginning on day 11 of activity) were arbitrarily defined. Data obtained from the 147 patients registered during the early period revealed 134 (91%) surgical patients and 13 (9%) medical patients. 88% of them needed specialized care for traumatic orthopaedic lesions and procedures under anesthesia or sedation were mainly (98%) performed for traumatic conditions. Data obtained for the 324 patients registered during the late period revealed 110 (34%) surgical patients and 214 (66%) medical patients. There was a switch from high surgical needs to more routine medical and surgical care, with less procedures under anesthesia or sedation (88%) for the treatment of traumatic lesions.

See pages 97 - 144 for financial disclosure information.



**Conclusion:** Pediatric orthopaedic surgeons have a major role to play in the early phase of relief response to potentially minimize long-term physical and psychosocial disability associated with these complex injuries in growing patients.

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See pages 97 - 144 for financial disclosure information.

## OTA Research Fund Form

### ORTHOPAEDIC TRAUMA ASSOCIATION RESEARCH FUND - 2012

The OTA Research Fund is used to help fund peer reviewed orthopaedic trauma research, including multi-center studies, and to support OTA educational programs.

*Make check payable to:*

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- OTA Approved Research Grants  
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 Either OTA Approved Research or Education Grants

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<b>Diamond Award</b>	\$150,000 and above
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## **Mission Statement**

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The mission of the Orthopaedic Trauma Association (OTA) is to promote excellence in care for the injured patient, through provision of scientific forums and support of musculoskeletal research and education of orthopaedic surgeons and the public.

## **Vision Statement**

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The OTA will be the authoritative source for the optimum treatment and prevention of musculoskeletal injury, will effectively communicate this information to the orthopaedic and medical community and will seek to influence health care policy that effect care and prevention of injury.

## **Value Statement**

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The OTA is adaptable, forward thinking and fiscally responsible and is composed of a diverse worldwide membership who provide care and improve the knowledge base for the treatment of injured patients. OTA members provide worldwide leadership through education, research and patient advocacy.

## **Scientific Meeting Objectives**

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The OTA is an organization dedicated to the discovery and dissemination of knowledge and information regarding the prevention, diagnosis, and treatment of musculoskeletal injuries. The 28th Annual Meeting of the OTA will provide all registrants the opportunity to witness presentations of peer-reviewed original basic science and clinical research papers, posters and symposia that present current concepts for topics of general interest. A multitude of mini-symposia, bio-skills labs, informal case presentations, and technical exhibits, each with specific focus, will enable a customized educational experience.

Research sessions will include: original paper presentations dedicated to specific anatomic injury and original basic science papers.

Educational objectives will be fulfilled through the presentation of scientific presentations and symposia with subsequent discussions in an open forum. Ample opportunity will be available to express common concern, share relevant experiences and provide alternative treatment approaches.

General themes of orthopaedic trauma care will also be presented by topic focused symposia, motor skills laboratories, case presentations, scientific poster presentations and technical exhibits.

The American Academy of Orthopaedic Surgeons designates this live activity for a maximum of **20 AMA PRA Category 1 Credits™**. Physicians should claim only the credit commensurate with the extent of their participation in the activity.



## ACCREDITATION – CME INFORMATION

This 28th Annual Meeting of the Orthopaedic Trauma Association has been planned and implemented in accordance with the Essential Areas and policies of the Accreditation Council for Continuing Medical Education through the joint sponsorship of the American Academy of Orthopaedic Surgeons and the Orthopaedic Trauma Association. The American Academy of Orthopaedic Surgeons is accredited by the ACCME to provide continuing medical education for physicians.

The American Academy of Orthopaedic Surgeons designates this live activity for a maximum of **20 AMA PRA Category 1 Credits™**. Physicians should claim only the credit commensurate with the extent of their participation in the activity.



## FDA STATEMENT

Some drugs or medical devices demonstrated at this 28th Annual Meeting may not have been cleared by the FDA or have been cleared by the FDA for specific purposes only. The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

Academy policy provides that “off label” uses of a drug or medical device may be described in the Academy’s CME activities so long as the “off label” use of the drug or medical device is also specifically disclosed (i.e., it must be disclosed that the FDA has not cleared the drug or device for the described purpose). Any drug or medical device is being used “off label” if the described use is not set forth on the product’s approval label.

- Indicates those faculty presentations in which the FDA has not cleared the drug and/or medical device for the use described (i.e., the drug or medical device is being discussed for an “off label” use).

## DISCLAIMER

The material presented at the 28th Annual Meeting has been made available by the *Orthopaedic Trauma Association* for educational purposes only. The material is not intended to represent the only, nor necessarily best, method or procedure appropriate for the medical situations discussed, but rather is intended to present an approach, view, statement or opinion of the faculty which may be helpful to others who face similar situations.

The Orthopaedic Trauma Association disclaims any and all liability for injury or other damages resulting to any individual attending the Annual Meeting and for all claims which may arise out of the use of the techniques demonstrated therein by such individuals, whether these claims shall be asserted by physician or any other person.

## DISCLOSURE

The names of authors presenting the papers at the 28th Annual Meeting are printed in **boldface**.

As an accredited provider of continuing medical education CME, the Academy and OTA are required by the Accreditation Council for Continuing Medical Education (ACCME) to obtain and share with participants of an OTA CME activity any potential conflicts of interest by faculty, program developers and CME planners.

The ACCME Standards of Commercial Support, Standard 2 states the requirements:

- 2.1 The provider must be able to show that everyone who is in a position to control the content of an education activity has disclosed all relevant financial relationships with any commercial interest to the provider.
- 2.2 An individual who refuses to disclose relevant financial relationship will be disqualified from being a planning committee member, a teacher, or an author of CME, and cannot have control of, or responsibility for the development, management, presentation or evaluation of the CME activity.

The AAOS disclosure policy requires that faculty submit all financial relationships occurring within the past 12 months that create a potential conflict.

Each participant in the Annual Meeting has been asked to disclose if he or she has received something of value from a commercial company or institution, which relates directly or indirectly to the subject of their presentations.

Authors who completed their financial disclosures have identified the options to disclose as follows:

- n. Respondent answered 'No' to all items indicating no conflicts;
1. Royalties from a company or supplier;
2. Speakers bureau/paid presentations for a company or supplier;
- 3A. Paid employee for a company or supplier;
- 3B. Paid consultant for a company or supplier;
- 3C. Unpaid consultant for a company or supplier;
4. Stock or stock options in a company or supplier;
5. Research support from a company or supplier as a PI;
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7. Royalties, financial or material support from publishers;
8. Medical/orthopaedic publications editorial/governing board;
9. Board member/committee appointments for a society.

An indication of the participant's disclosure appears after his/her name in the alphabetical listing along with the commercial company or institution that provided the support.

The Academy and OTA do not view the existence of these disclosed interests or commitments as necessarily implying bias or decreasing the value of the author's participation in the meeting.

Δ Indicates presentation was funded by a grant from the Orthopaedic Trauma Association.

**Cameras or video cameras may not be used in any portion of the meeting.**



## **PHILOSOPHY**

In order to promote transparency and confidence in the educational programs and in the decisions of the Orthopaedic Trauma Association (hereinafter collectively referred to as “OTA”), the OTA Board of Directors has adopted this mandatory disclosure policy.

The actions and expressions of Fellows, Members, and Others providing education of the highest quality, or in shaping OTA policy, must be as free of outside influence as possible, and any relevant potentially conflicting interests or commercial relationships must be disclosed. Because the OTA depends upon voluntary service by Fellows, Members, and Others to conduct its educational programs and achieve its organizational goals, this disclosure policy has been designed to be realistic and workable.

*The OTA does not view the existence of these interests or relationships as necessarily implying bias or decreasing the value of your participation in the OTA.*

## **OBLIGATION TO DISCLOSE**

Each participant in an OTA CME program or author of enduring materials, and members of the OTA Board of Directors, Committees, Project Teams or other official OTA groups (collectively “OTA governance groups”), has the obligation to disclose all potentially conflicting interests.

Using a uniform form approved by the OTA Board of Directors, participants are responsible for providing information to the OTA (the OTA will accept either disclosure forms submitted directly to the OTA, or disclosure information submitted through the AAOS on-line Disclosure Program). Participants are responsible for the accuracy and completeness of their information. In addition, participants who disclose via the AAOS on-line Disclosure Program have an obligation to review and update their personal information in the AAOS Orthopaedic Disclosure Program at least semiannually (usually April and October). It is recommended that participants note any changes to the AAOS Orthopaedic Disclosure Program as soon as possible after they occur.

Failure of a required participant to disclose will result in the participant being asked not to participate in the OTA CME program and OTA governance groups.

A list of all participants in OTA CME programs and OTA governance groups, along with their disclosures, will be included in all meeting materials.

Participants in OTA governance groups have an obligation to indicate any potential conflicts they may have during discussions affecting their personal interests during the meeting of the OTA governance group. At each meeting of the OTA governance group, members of the group will be reminded that full disclosure must be made of any potential conflict of interest when a matter involving that interest is discussed.

The chair of the governance group shall also have the prerogative of requesting a participant to provide further information or an explanation if the chair identifies a potential

conflict of interest regarding that participant. Based on the information provided in the OTA Orthopaedic Disclosure Program and/or upon a further review, the chair of the OTA governance group may determine that the participant shall:

Disclose the conflict and continue to participate fully in the OTA governance group's deliberations

Disclose the conflict, but abstain from discussing and voting on the matter; or

Disclose the conflict and leave the room until the matter has been fully discussed and acted upon.

If one of the latter two actions is taken, it should be reflected in the minutes of the OTA governance group's meeting.

Discussions at OTA meetings often cover a broad range of topics pertinent to the interests or concerns of orthopaedic surgeons. As a general rule, except as noted below, discussions at OTA meetings can address virtually any topic without raising antitrust concerns if the discussions are kept scrupulously free of even the suggestion of private regulation of the profession. However, a number of topics that might be (and have been) discussed at OTA meetings may raise significant complex antitrust concerns. These include:

- Membership admissions, rejections, restrictions, and terminations;
- Method of provision and sale of OTA products and services to non-members;
- Restrictions in the selection and requirements for exhibitors at the OTA Annual Meeting or in CME activities;
- Establishment of the professional compliance program and adoption of Standards of Professionalism;
- Collecting and distributing certain orthopaedic practice information, particularly involving practice charges and costs;
- Obtaining and distributing orthopaedic industry price and cost information;
- Professional certification programs;
- Group buying and selling; and
- Inclusions or exclusion of other medical societies in organizational activities or offerings.

When these and related topics are discussed, the convener or members of the OTA group should seek counsel from Legal Counsel.

OTA urges its Board, committees and other groups not to participate in discussions that may give the appearance of or constitute an agreement that would violate the antitrust laws.

Notwithstanding this reliance, it is the responsibility of each OTA Board or committee member to avoid raising improper subjects for discussion. This reminder has been prepared to ensure that OTA members and other participants in OTA meetings are aware of this obligation.

The “Do Not’s” and “Do’s” presented below highlight only the most basic antitrust principles. OTA members and others participating in OTA meetings should consult with the OTA Presidential Line and/or General Counsel in all cases involving specific questions, interpretations or advice regarding antitrust matters.

#### **Do Not's**

1. Do not, in fact or appearance, discuss or exchange information regarding:
  - a. Individual company prices, price changes, price differentials, mark-ups, discounts, allowances, credit terms, etc. or any other data that may bear on price, such as costs, production, capacity, inventories, sales, etc.
  - b. Raising, lowering or “stabilizing” orthopaedic prices or fees;
  - c. What constitutes a fair profit or margin level;
  - d. The availability of products or services;
  - e. The allocation of markets, territories or patients.

2. Do not suggest or imply that OTA members should or should not deal with certain other persons or firms.
3. Do not foster unfair practices regarding advertising, standardization, certification or accreditation.
4. Do not discuss or exchange information regarding the above matters during social gatherings, incidental to OTA-sponsored meetings.
5. Do not make oral or written statements on important issues on behalf of OTA without appropriate authority to do so.

## **Do**

1. Do adhere to prepared agenda for all OTA meetings. It is generally permissible for agendas to include discussions of such varied topics as professional economic trends, advances and problems in relevant technology or research, various aspects of the science and art of management, and relationships with local, state or federal governments.
2. Do object whenever meeting summaries do not accurately reflect the matters that occurred.
3. Do consult with OTA counsel on all antitrust questions relating to discussions at OTA meetings.
4. Do object to and do not participate in any discussions or meeting activities that you believe violate the antitrust laws; dissociate yourself from any such discussions or activities and leave any meeting in which they continue.

## **Special Guidelines for Collecting and Distributing Information**

The collection and distribution of information regarding business practices is a traditional function of associations and is well-recognized under the law as appropriate, legal and consistent with the antitrust laws. However, if conducted improperly, such information gathering and distributing activities might be viewed as facilitating an express or implied agreement among association members to adhere to the same business practices. For this reason, special general guidelines have developed over time regarding association's reporting on information collected from and disseminated to members. Any exceptions to these general guidelines should be made only after discussion with the Office of General Counsel. These general guidelines include:

1. Member participation in the statistical reporting program is voluntary. The statistical reporting program should be conducted without coercion or penalty. Non-members should be allowed to participate in the statistical reporting program if eligible; however, if there is a fee involved, they may be charged a reasonably higher fee than members.
2. Information should be collected via a written instrument that clearly sets forth what is being requested.
3. The data that is collected should be about past transactions or activities; particularly if the survey deals with prices and price terms (including charges, costs, wages, benefits, discounts, etc.), it should be historic, i.e., more than three months old.
4. The data should be collected by either the OTA or an independent third party not connected with any one member.
5. Data on individual orthopaedic surgeons should be kept confidential.

6. There should be a sufficient number of participants to prevent specific responses or data from being attributable to any one respondent. As a general rule, there should be at least five respondents reporting data upon which any statistic or item is based, and no individual's data should represent more than 25% on a weighted average of that statistic or item.
7. Composite/aggregate data should be available to all participants – both members and nonmembers. The data may be categorized, e.g., geographically, and ranges and averages may be used. No member should be given access to the raw data. Disclosure of individual data could serve to promote uniformity and reduce competition.
8. As a general rule, there should be no discussion or agreement as to how members should adjust, plan or carry out their practices based on the results of the survey. Each member should analyze the data and make business decisions independently.

# OTA Specialty Day

March 23, 2013

Chicago, Illinois

Planning Committee: *Robert A. Probe, MD, OTA President*

*M. Bradford Henley, MD, Clifford B. Jones, MD, Robert F. Ostrum, MD,  
David C. Teague, MD, David B. Thordarson, MD, Paul Tornetta, III, MD*

**Featuring:**

## **To Fix or How to Fix: That Is the Evidence Based Question**

Moderator: *William T. Obremskey, MD*

Presenters: *Michael R. Baumgaertner, MD, Douglas P. Hanel, MD,  
J. Lawrence Marsh, MD, Michael D. McKee, MD, Emil H. Schemitch, MD*

## **Managing Osteoporotic Fractures:**

### **How to Be on Top of Your Game and Avoid Complications!**

Moderator: *Clifford B. Jones, MD*

Presenters: *Charles M. Court-Brown, MD, Paul J. Duwelius, MD,  
Michael J. Gardner, MD, Stephen L. Kates, MD, Richard F. Kyle, MD, William N. Levine, MD*

## **Trauma Techniques: Top Videos**

Moderator: *Robert F. Ostrum, MD*

Presenters: *Andrew R. Burgess, MD, Michael J. Gardner, MD,  
Erik Kubiak, MD, David C. Ring, MD, Andrew H. Schmidt, MD*

## **New Tips and Tricks from the OTA Annual Meeting for your Trauma Practice**

Moderator: *James A. Goulet, MD*

## **Case-Based Nonunion Management**

Moderator: *Paul Tornetta, III, MD*

Presenters: *Mark R. Brinker, MD, Roy Sanders, MD,  
Heather A. Vallier, MD, Donald A. Wiss, MD*

## **OTA / AOFAS Combined Session: Controversies and Complications in Trauma of the Foot and Ankle**

### **Lisfranc Injuries: Fusion vs ORIF**

Moderator: *Robert B. Anderson, MD*

Presenters: *J. Chris Coetzee, MD, Ross K. Leighton, MD*

### **Calcaneus: - Extensile vs Minimally Invasive**

Moderator: *Roy Sanders, MD*

Presenters: *Stephen K. Benirschke, MD,  
Dr. med. Stefan Rammelt, Bruce J. Sangeorzan, MD*

### **Ankle: Syndesmosis Controversies**

Moderator: *William C. McGarvey, MD*

Presenters: *John S. Early, MD,  
Paul Tornetta, III, MD, William C. McGarvey, MD,*

### **Ankle: Posterior Malleolus: To Fix or Not to Fix**

Moderator: *Robert A. Probe, MD*

Presenters: *Dean G. Lorich, MD, David B. Thordarson, MD*



# Save the Date



*Photo courtesy of JW Marriott Phoenix Desert Ridge Resort & Spa.*

## OTA 29<sup>th</sup> Annual Meeting October 10 – 12, 2013 Phoenix, Arizona

*Andrew H. Schmidt, MD, OTA 2013 – 2014 President  
Thomas F. Higgins, MD, Program Chair  
Laura J. Prokuski, MD, Local Host*

## Pre-Meeting Courses: October 9 – 12, 2013

*International Orthopaedic Trauma Care Forum  
Masters Level Trauma Coding Course  
Basic Science Focus Forum  
Young Practitioners Forum  
Grant Writing Workshop  
Ortho Trauma for NP's and PA's  
Ortho Trauma Boot Camp  
Ortho Trauma Nursing Course*

# Orthopaedic Trauma On-Line Educational Resources



## Orthopaedic Trauma Techniques Video & Lecture Library

Coming soon to the AAOS OrthoPortal....an orthopaedic trauma video techniques library!

The OTA Education Committee is seeking high-quality surgical techniques videos. Be a part of the team currently working to develop what will soon be the premier site for peer-reviewed trauma surgical techniques videos.

Please contact Bill Ricci, OTA Education Committee Chair or Bob Ostrum, Video Library Director to volunteer at [OTA@aaos.org](mailto:OTA@aaos.org).

## 2012 / 2013 Webinar Schedule

### **Ankle Fractures are Not Always Simple: Identification and Management of Subtle Complexities**

Moderator: Paul Tornetta, III, MD

Faculty: Ken Egol, MD and David Sanders, MD

*View this Webinar on the OrthoPortal*

October 23<sup>rd</sup> – 7:30 p.m. CDT

### **Clavicle Fractures: When and How to Fix Them**

Moderator: Mike McKee, MD

Presenters: Carl Basamania, MD, Kyle Jeray, MD, Dave Ruch, MD

Clavicle Fractures webinar  
sponsored by

**stryker**

## 2013 Webinars

(Visit the OTA or AAOS website for details)

- Proximal Humerus Fractures: Decision Making and Methods
- Managing Challenging Hip Fractures
- Tibial Shaft Fractures: The State of the Starting Point, Nailing Extreme Proximal and Distal Fractures, and Basics of Open Fracture Management.
- Surviving a Night on Call:  
The Current State of Orthopaedic Urgencies and Emergencies
- Periprosthetic Femoral Shaft and Supracondylar Fractures Femur Fractures –  
General Principles and Role for Locked Plates and Revision Arthroplasty?
- Common Upper Extremity Fractures: The When and How of Surgical Management