6300 North River Road, Suite 727
Rosemont, IL 60018-4226
Phone: (847) 698-1631
FAX: (847) 823-0536
E-mail: ota@aaos.org

ORTHOPAEDIC TRAUMA ASSOCIATION

Andrew H. Schmidt, MD

Dear OTA Annual Meeting Attendee:

It is my pleasure to welcome you to Phoenix for the 29th Annual Meeting of the Orthopaedic Trauma Association. During the next few days, you will have the opportunity to hear speakers from around the world present cutting-edge research on a variety of topics. You may attend plenary sessions on outcomes, assessment of fracture repair, and operative vs. nonoperative management of upper extremity fractures. You may choose from a number of smaller mini-symposia or case-presentations, and perhaps you will take the opportunity to participate in one of our popular pre-meeting events such as our Fracture Coding course, the Basic Science Focus Forum, the International Trauma Care Program, or the Orthopaedic Boot Camp, among others. I am confident that the educational strength and innovation of this year's program, assembled under the leadership of Thomas Higgins, MD, Annual Meeting Program Chair and the Program Committee, can be customized to guarantee an exceptional educational experience for each attendee.

We are honored to recognize China as our Guest Nation this year. Members of the Chinese Orthopaedic Trauma Society will be making several interesting presentations at the International Trauma Care Forum.

Thank you for attending our meeting this year. I know that you will return to your practice as excited and enthused as ever to be part of the world of orthopaedic traumatology.

Andrew H. Schmidt, MD
OTA President

Welcome

OTA Membership Directory available at 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.
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Orthopaedic Trauma Association

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Rosemont, IL 60018-4226, USA
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Home Page: http://www.ota.org

OTA Staff

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

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SCIENTIFIC POSTERS *Grand Saguaro Foyer*

Open: Thursday 1:00 pm – Saturday 1:30 pm

TECHNICAL EXHIBITS *Grand Canyon Ballroom*

Open:	Thursday	2:50 pm	-	5:00 pm
	Friday	9:00 am	-	5:00 pm
	Saturday	9:00 am	-	1:00 pm

SPEAKER READY ROOM *Grand Saguaro Foyer*

4:00 pm - 6:00 pm – Tuesday
Open 6:00 am 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	
Michael W. Chapman, MD	1985-87
Charles C. Edwards, MD	1987-88
John A. Cardea, MD	1988-89
Bruce D. Browner, MD	1989-90
Joseph Schatzker, MD	1990-91
Richard F. Kyle, MD	1991-92
Robert A. Winquist, MD	1992-93
Peter G. Trafton, MD	1993-94
Kenneth D. Johnson, MD	1994-95
Alan M. Levine, MD	1995-96
Lawrence B. Bone, MD	1996-97
James F. Kellam, MD	1997-98
David L. Helfet, MD	1998-99
Andrew R. Burgess, MD	1999-00
M. Bradford Henley, MD, MBA	2000-01
Donald A. Wiss, MD	2001-02
Thomas A. Russell, MD	2002-03
Marc F. Swiontkowski, MD	2003-04
Roy Sanders, MD	2004-05
Paul Tornetta, III, MD	2005-06
Michael J. Bosse, MD	2006-07
Jeffrey O. Anglen, MD	2007-08
J. Tracy Watson, MD	2008-09
David C. Templeman, MD	2009-10
Timothy J. Bray, MD	2010-11
Andrew N. Pollak, MD	2011-12
Robert A. Probe, MD	2012-13

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
October 3 - 6, 2012	Minneapolis, Minnesota, USA

ORTHOPAEDIC TRAUMA ASSOCIATION ORGANIZATION

2013 BOARD OF DIRECTORS

Andrew H. Schmidt, MD
President

Ross K. Leighton, MD
President Elect

Theodore Miclau, III, MD
2nd President Elect

David J. Hak, MD
CFO

Heather A. Vallier, MD
Secretary

Robert A. Probe, MD
Immediate Past President

ORTHOPAEDIC TRAUMA ASSOCIATION ORGANIZATION

2013 BOARD OF DIRECTORS, continued

Timothy J. Bray, MD
2nd Past President

Lisa K. Cannada, MD
Member-at-Large

Douglas W. Lundy, MD
Member-at-Large

David C. Teague, MD
Member-at-Large

Thomas F. Higgins, MD
Annual Program

ORTHOPAEDIC TRAUMA ASSOCIATION ORGANIZATION

NOMINATING
(Elected Committee)
Robert Probe, (Chair 2014 Slate)
Bruce Browner
Toni McLaurin
Jeffrey Smith
Attila Poka

MEMBERSHIP
(Elected Committee)
Clifford Jones (Chair)
Nirmal Tejwani
Richard Buckley
David Sanders
Peter Cole

ANNUAL MEETING ARRANGEMENTS
Laura Prokuski
(Phoenix, AZ 2013 Local Host)
Roy Sanders & H. Claude Sagi
(Tampa, FL 2014 Local Hosts)

ANNUAL PROGRAM
Thomas Higgins (Chair)
Robert O'Toole (Co-Chair)
Michael Gardner
Pierre Guy
Stephen Kottmeier
Michael McKee
Gilbert Ortega
John Ruth
David Sanders
Basic Science Sub-Committee
Chair (*ex officio*): Theodore Miclau
Coding Course
Chair (*ex officio*): Scott Broderick

Basic Science Sub-Committee
Theodore Miclau (Chair)
Steve Olson
Mohit Bhandari
Joseph Borrelli
Edward Harvey
Emil Schemitsch
Research Committee Chair (*ex officio*):
Todd McKinley

BY-LAWS & HEARINGS
James Stannard (Chair)
Mark Anders
Alexandra Schwartz

CLASSIFICATION & OUTCOMES
Craig Roberts (Chair)
Andrew Evans
Roman Hayda
Matthew Karam
Daniel Stinner
Nirmal Tejwani
Gregory Zych
Julie Agel (Presidential Consultant)
James Kellam (Presidential Consultant)
J. Lawrence Marsh (Presidential Consultant)

Ad Hoc, Open Fx Work Group:
Milan Sen
Debra Sietsema

DISASTER MANAGEMENT PREPAREDNESS
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Mark McAndrew
Christian Mamczak
Eric Pagenkopf
Mark Richardson
David Teague
Philip Wolinsky

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William Ricci (Chair)
Paul Dougherty
Samir Mehta
Robert Ostrum
Marcus Sciadini
Paul Tornetta, III
OKO Ex-Officio Member:
Thomas DeCoster
Ex-officio Resident Member:
Michael Beltran, MD

Education Sub-Committee
Michael Archdeacon – RCFC, Chair
Kyle Jeray – RCFC, Co-Chair
Matt Graves – Spring RCFC Chair
Gregory Della Rocca – Spring RCFC Co-Chair
Kenneth Koval – Core Curriculum Syllabus, Chair
Brett Crist – RATTC, Chair
Matthew Mormino – RATTC, Co-Chair
Steven Morgan – AAOS/OTA Course, Chair (2012 – 2013)
Frank Liporace – AAOS/OTA Course, Co-Chair (2013 – 2014)
Kenneth Koval – AAOS/OTA Course, Co-Chair (2014 – 2015)
Roy Sanders – JOT Editor
Erik Kubiak – Video Library Subcommittee

EVIDENCE BASED QUALITY, VALUE, SAFETY
William Obremskey (Chair)
Jaimo Ahn
Bruce Browner
Cory Collinge
Arvind Nana
Steven Olson
Claude Sagi
Paul Tornetta, III

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Cory Collinge
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Madhav Karunakar
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Roy Sanders
Lisa Taitsman
Presidential Consultant:
J. Tracy Watson
Ex-Officio Fellow Members:
Jason Sansone, Jennifer Wood

Fellowship Match Compliance Sub-Committee
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Clifford Jones
Steven Kottmeier

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Douglas Dirschl

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Brendan Patterson
Edward Perez
Michael Sirkin
Rena Stewart
J. Tracy Watson
Ex-officio: David Hak, OTA CFO,
Todd McKinley, Research Chair

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Michael Suk (Chair)
Sam Agnew
Alex Jahangir
Clifford Jones
Toan Le
Samir Mehta
Manish Sethi
Philip Wolinsky
Bruce Ziran
Ex-Officio Liaison: Bruce Browner

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Jeffrey Anglen
Peter Giannoudis
Amir Matityahu
Massimo Morandi
Steven Morgan
Saqib Rehman
Pat Yoon
Lewis Zirkle

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Ney Amaral (Brazil)
Guenter Lob (Germany)
Akira Oizumi (Japan)
Hans-Christoph Pape (Germany)
Toney Russell (China focus)

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COL Romney Andersen, Chair (Army)
CDR Mark Fleming (Walter Reed)
Kevin Kuhn (San Diego)
Christopher LeBrun
COL (Ret) Mark Richardson (Air Force)
LCDR(S) Christopher Smith (Portsmouth)
MAJ Daniel Stinner (BAMC)
CAPT William Todd (Hospital Ships)
MAJ Eric Verweibe (LRMC)

PAST PRESIDENT LIAISON
Robert Probe, Immediate Past President (Chr)
All Past OTA Presidents

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Scott Broderick (Chair)
Paul Appleton
Lisa Cannada
Anthony Infante
James Krieg
Frank Liporace
Brent Norris
Presidential Consultants:
Brad Henley; William Creevy

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Robert Crous
Josh Gary
Jake Heiney
Alex Jahangir
Hassan Mir
Massimo Morandi

Ad Hoc
YOC Project Team:
Co-Chairs: Brett Crist and Robert Dunbar

Newsletter
Hassan Mir, Editor
Joshua Gary, Co-editor

RESEARCH
Todd McKinley (Chair)
Donald Anderson
Timothy Bhattacharyya
Brett Crist
Gregory Della Rocca
Bradley Merk
Saam Morshaad
Brian Mullis
Steven Olson
George Russell
Walter Virkus
Robert Zura

ORTHOPAEDIC ORGANIZATIONAL LIAISONS

AAOS Board of Specialty Societies
Andrew Schmidt – Presidential Line Representative
Lisa Cannada – Communications
Michael Suk – Health Policy
William Ricci – Education
Todd McKinley – Research
David Templeman – BOS Chair-Elect
Lisa Cannada – BOS Match Oversight Committee Chair
Mark Lee – BOS Match Oversight Committee OTA Rep
Kathleen Caswell – ED Representative

ACS COT (American College of Surgeons Committee on Trauma)
COT Orthopaedic Members
(Completes tenure)
Wade R. Smith (Chair) (2014)
Gregory J. Della Rocca (2017)
Gregory M. Georgiadis (2016)
Langdon A. Hartsock (2017)
Douglas W. Lundy (2014)
Philip R. Wolinsky (2016)
Bruce Ziran (2019)
Vacancy (2018)

Other Orthopaedic Liaison Positions
Peter Trafton – USBJDI Board of Directors: Member-at-Large
Marc Swiontkowski – EWI
Nominated 2011 as Civilian Rep
Steven Olson (Chair) – AAOS Hip Fracture Best Practices Steering Committee (HFBPSC)

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:

Dennis J. Beck, MD
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
Thomas A. DeCoster, MD
Gregory J. Della Rocca, MD, PhD
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. Lorich, 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
Gregory M. Osgood, MD
Brendan M. Patterson, MD
Laura J. Prokuski, MD
Edward K. Rodriguez, MD, PhD
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
Carla S. Smith, 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:
    - Demonstrated commitment to teaching and leadership in orthopaedic trauma
    - 5 years of trauma experience following ABOS certification

If interested please contact the OTA Business Office, and include your CV: 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)
Mc Lean, Virginia

Fred F. Behrens, MD (2005)
Newark, New Jersey

John Border, MD (1997)
Buffalo, New York

Spencer L. Butterfield, MD (2007)
Cincinnati, Ohio

James Bradley Carr, MD (2011)
Roanoke, Virginia

Thomas H. Comfort, MD (1990)
Minneapolis, Minnesota

John F. Connolly, MD (2007)
Orlando, Florida

Kathryn E. Cramer, MD (2005)
Detroit, Michigan

Bertram Goldberg, MD (1995)
Englewood, Colorado

Edward T. Habermann, MD (2009)
Chappaqua, New York

J. Paul Harvey, Jr., MD (2010)
Pasadena, California

Kenneth D. Johnson, MD* (2003)
Placitas, New Mexico

Emile Letournel, MD (1994)
Paris, France

Alan Marc Levine, MD* (2009)
Baltimore, Maryland

CDR Michael T. Mazurek, MD (2009)
San Diego, California

Spencer Roy McLean, MD (2013)
Calgary, Alberta, Canada

William J. Mills, III, MD (2011)
Anchorage, Alaska

Maurice Müeller, MD (2009)
Bern, Switzerland

John A. Ogden, MD (2011)
Atlanta, Georgia

Howard Rosen, MD (2000)
New York, New York

Joseph F. Slade, III, MD (2010)
Guilford, Connecticut

Phillip G. Spiegel, MD (2008)
Englewood, Florida

Clifford H. Turen, MD (2013)
Dover, Delaware

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 7 in memory of their commitment to education, research and patient care.

2012 – ***Charles J. Jordan, MD, Resident Award Winner***
•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

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 Dielwart, 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. Petrisor, 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://signfracturecare.org.

Congratulations to the following OTA/SIGN Scholarship Winners:

2013 – ***Billy Thomson Haonga, MD****, Dar -Se Salaam, Tanzania*
Innocent Chiedu Ikem, MD*, Ile-Ife, Osun State, Nigeria*

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

Δ OTA Grant

- 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 496.

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.

2012 – Orthopaedic Trauma – My Perspective
James F. Kellam, MD, FRCS(C), FACS

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, Jr., 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.)

2012 – 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

2011 – Posterolateral Antiglide Versus Lateral Plating for SE Pattern Ankle Fractures: A Multicenter Randomized Control Trial
Paul Tornetta, III, MD[1]*; Laura S. Phieffer, MD[2]; Clifford B. Jones, MD[3]; Janos P. Ertl, MD[4]; Brian H. Mullis, MD[4]; Kenneth A. Egol, MD[5]; Michael J. Gardner, MD[6]; William M. Ricci, MD[6]; David C. Teague, MD[7]; William Ertl, MD[7]; Cory A. Collinge, MD[8]; Ross K. Leighton, MD[9]; Ojas Joshi, MS[1]*
[1]Boston University Medical Center, Boston, Massachusetts, USA;
[2]Ohio State University Medical Center, Columbus, Ohio, USA;
[3]Orthopaedic Associates of Michigan, Grand Rapids, Michigan, USA;
[4]Indiana University, Indianapolis, Indiana, USA;
[5]NYU Hospital for Joint Disease, New York, New York, USA;
[6]Washington University, St. Louis, Missouri, USA
[7]University of Oklahoma, Oklahoma City, Oklahoma, USA;
[8]Orthopaedic Associates – Fort Worth, Fort Worth, Texas, USA;
[9]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

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 JH. 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. Veilette, MD; Daniel B. Whelan, MD; James P. Waddell, MD; David J.G. Stephen, MD; Terrence Axelrod, MD; Gregory Berry, MD; Bertrand Perey, MD; Kostas Panagiotopolus, 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*

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

2001 – Pertrochanteric Fractures: Is There an Advantage to an Intramedullary Nail?
Richard E. Stern, MD; *Christophe Sadowski, MD; Anne Lübbeke, 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)

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*

* Something of value received.
Δ OTA Grant

ACKNOWLEDGMENTS

The Orthopaedic Trauma Association gratefully acknowledges the following foundations, 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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(as of July 31, 2013)

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Thank

OTA Legacy Society

NEW this year, the OTA will introduce an **OTA Legacy Society**,
for those who have contributed $10,000 and greater during their lifetime giving.
It is an honor to announce our first OTA Legacy Society members:

James C. Binski, MD
Kathryn E. Cramer, MD
William R. Creevy, MD
Orthopaedic Trauma Service, Florida Orthopaedic Institute, Tampa, FL
Orthopaedic Specialists of North America, Phoenix, AZ
Andrew H. Schmidt, MD
Marc F. Swiontkowski, MD
David C. Templeman, MD
Paul Tornetta, III, MD

2013 Members Award ($1,000 - $4,999)

Michael Bosse, Tim Bray, Bruce Buhr, Lisa Cannada, William Creevy, Douglas Dirschl, Stuart Gold, David Hak, Thomas Higgins, Kyle Jeray, Ross Leighton, Doug Lundy, Hal Martin, Ted Miclau, Steve Morgan, Timothy O'Mara, Andrew Pollak, Robert Probe, William Ricci, Andrew Schmidt, Daniel Sheerin, Jeff Smith, Scott T. Smith, David Teague, David Templeman, Paul Tornetta, Heather Vallier, John Weinlein, Sharese White

2013 Friends Award ($250 - $999)

Mark Adams, Paul Appleton, Kathleen Caswell, Carl DePaula, Nicholas Dinicola, Darin Freiss, Gerald Greenfield, Jr., William Kurtz, Mark Olson, Michael Prayson, Mark Reilly, Regis Renard, Edward K. Rodriguez, Melvin Rosenwasser, David Sanders, Susan Scherl, Michael Sirkin, Lisa Taitsman, Gregory Vrabec, Matthew Weresh, Thomas Wuest, Harris Yett, Lewis Zirkle

2013 Associates Award (up to $249)

Yelena Bogdan, Kevin Luttrell, Bryan Ming, Dominque Rouleau, John Staeheli, Kyle Swanson, Michael Swords, Ryan Will

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ACKNOWLEDGMENTS

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Peter Cole, Curt Comstock, William Creevy, Gregory Della Rocca, William DeLong,
James Goulet, David Hak, Steven Haman, Kyle Jeray, Alan Jones, Clifford Jones,
Ross Leighton, Paul Levin, Douglas Lundy, Hal Martin, Simon Mears,
Theodore Miclau III, Steven Morgan, Timothy O'Mara, Edward Perez,
Andrew Pollak, Robert Probe, Matthew Rudloff, Thomas Russell, Andrew Schmidt,
Brian Sears, Scott Smith, Rena Stewart, David Teague, David Templeman,
Paul Tornetta III, Heather Vallier, J. Tracy Watson, David Weisman

ACKNOWLEDGMENTS

Friends Award ($250 - $999)

Mark Adams, A. Herbert Alexander, Daniel Altman, Jeffrey Anglen, Paul Appleton, Emil Azer, James Binski, Brett Bolhofner, Timothy Bonatus, Christopher Born, Christina Boulton, Julius Brecht, Bruce Buhr, Kathleen Caswell, Michael Chapman, William Craig III, Brett Crist, Carl DePaula, Mark Dodson, Christopher Doro, W. Andrew Eglseder, Thomas Einhorn, Janos Ertl, Darin Freiss, Rajeev Garapati, Wilford Gibson, Stuart Gold, David Goodspeed, John Gorczyca, Thomas Goss, Andrew Green, Gerald Greenfield Jr., Jonathan Gross, Sigvard Hansen Jr., Roman Hayda, Darrell Hayes, David Helfet, Catherine Humphrey, Shepard Hurwitz, Utku Kandemir, Stephen Kates, Paul Lafferty, Gerald Lang, Richard Lange, Joshua Langford, Richard Laughlin, Mark Leberte, Dean Lorich, Steven Louis, Theodore Toan Le, Thaun Ly, John Lyden, Theodore Manson, Randall Marcus, Meir Marmor, R. Trigg McClellan, Saam Morshed, Jason Nascone, Brent Norris, William Obremskey, Mark Olson, Robert O'Toole, James Pape, Brendan Patterson, Michael Patzakis, Murat Pekmezci, Raymond Pensy, David Polonet, Michael Prayson, Matthew Putnam, Mark Reilly, Regis Renard, Craig Roberts, Gary Roberts, Jason Roberts, Edward Rodriguez, Melvin Rossenwasser, Thomas Russell, H. Claude Sagi, Bruce Sangeorzan, Andrew Saterbak, Gregory Schmeling, Robert Schultz, Marcus Sciadini, Karl Shively, Franklin D. Shuler, Robert Simpson Jr., Michael Sirkin, R. Malcolm Smith, Craig Smith, Wade Smith, James Stannard, Marc Swiontkowski, Lisa Taitsman, Jide Tinubu, Charles Versteeg Jr., Walter Virkus, David Volgas, Lawrence Webb, David Wellman, Matthew Weresh, Thomas Wuest, Edward Yang, Harris Yett, Lewis Zirkle, Robert Zura

Associates Award (up to $249)

Gregory Altman, Jose Bernardo Toro Arbelaez, Yelena Bogdan, Matt Graves, Peter Krause, Brian Miller, Arvind Nana, Saqib Rehman, Jeff Schulman, John Scolaro, Debra Sietsema, Michael Swords, Nirmal Tejwani, Timothy Weber, Marc Zussman

2012 OREF/OTA ENDOWMENT FUND CONTRIBUTIONS

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

Thanks

CENTER FOR ORTHOPAEDIC TRAUMA ADVANCEMENT ACKNOWLEDGMENTS

Center for Orthopaedic Trauma Advancement

COTA is grateful for the financial support during 2013 from
Smith & Nephew, Inc., *Stryker Orthopaedics*, and *DePuy Synthes Trauma.*

smith&nephew **$875,000**

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COMPANIES OF Johnson&Johnson

COTA supported fellowship programs for the 2013-2014 academic year as follows:

Allegheny General Hospital, Drexel University School of Medicine,
Pittsburgh, PA – *Daniel Altman, MD, Director*

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Hospital for Special Surgery, New York, NY – *David Helfet, MD, Director*

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Univ. of Washington, Harborview Medical Center, Seattle, WA – *David Barei, MD, Director*

Vanderbilt Orthopaedic Institute, Nashville, TN – *William Obremskey, MD, Director*

CENTER FOR ORTHOPAEDIC TRAUMA ADVANCEMENT ACKNOWLEDGMENTS

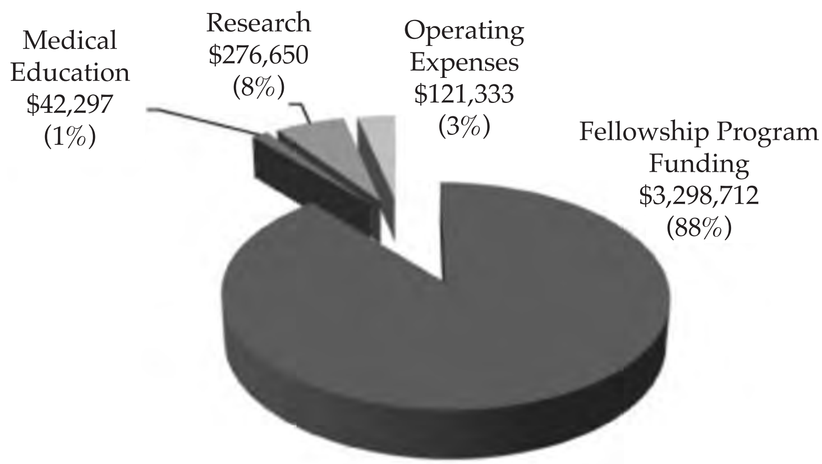
Wake Forest University Health Sciences, Winston-Salem, NC – *Eben Carroll, MD, Director*

Washington University School of Medicine,
Barnes-Jewish Hospital, St. Louis, MO – *William M. Ricci, MD, Director*

- **Fellowship Grants awarded for 2013-2014 = $1,000,000**
- **COTA/Smith & Nephew Education Grants awarded for 2013-2014 = $64,000**

COTA GIVING HISTORY

- **Fellowship Grants as of December 31, 2012 = $3,298,712**
- **Education Grants as of December 31, 2012 = $42,297**
- **Research Grants as of December 31, 2012 = $276,650**



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COTA office address: 6300 N. River Road, Rosemont, IL 60018-4226
website: www.cotagrants.org • e-mail address: office@cotagrants.org

OTA 2013 RESEARCH GRANT AWARD RECIPIENTS

(January 1, 2013 - December 31, 2013 Grant Cycle)

CLINICAL RESEARCH GRANTS (up to $40,000, up to 2-year grant cycle)

Title: **Does Residual Displacement After a Pelvic Ring Injury Impact Clinical Outcome?**
Principal Investigator: **Steven Olson, MD**
Co-Principal Investigator: **Kyle Jeray, MD**
Grant Funded by: **Zimmer/OTA**

Title: **A Multi-Center Prospective Cohort Study of Sacral Fractures Using Patient-Based and Objective Outcomes**
Principal Investigator: **Paul Tornetta, III, MD**
Co-Principal Investigator: **Julie Agel, MA**
Grant Funded by: **Smith & Nephew/OTA**

Title: **Locked Compression Plating versus Cable Plating Combined with Strut Allografts for Vancouver B1 Periprosthetic Femoral Fractures: A Randomized Controlled Trial**
Principal Investigator: **Aaron Nauth, MD**
Co-Principal Investigator: **Emil H. Schemitsch, MD**
Grant Funded by: **DePuy, A Johnson & Johnson Company/OTA**

BASIC RESEARCH GRANTS (up to $50,000, up to 2-year grant cycle)

Title: **A Comparison of Endothelial Progenitor Cell (EPC)–Based Gene Therapy versus Mesenchymal Stem Cell (MSC)–Based Gene Therapy for the Healing of Bone Defects**
Principal Investigator: **Aaron Nauth, MD**
Co-Principal Investigator: **Emil H. Schemitsch, MD**
Grant Funded by: **Smith & Nephew/COTA**

Title: **Infection Prevention In Long Bone Fracture Osteomyelitis Model Treated With IM Nail**
Principal Investigator: **Andrew H. Schmidt, MD**
Co-Principal Investigator: **Joan E. Bechtold, PhD**
Grant Funded by: **Smith & Nephew/COTA**

Title: **Discovering the Mechanism of Age-Associated Impaired Healing in the Presence of Sustained Inflammation**
Principal Investigator: **Theodore Miclau, MD**
Co-Principal Investigator: **Ralph Marcucio, PhD**
Grant Funded by: **Smith & Nephew/COTA**

Title: **Simulation Approaches for Training in Fluoroscopically Guided Articular Fracture Surgery**
Principal Investigator: **Matt Karam, MD**
Co-Principal Investigator: **Donald D. Anderson, PhD**
Grant Funded by: **OTA**

OTA 2013 RESEARCH GRANT AWARD RECIPIENTS, continued

$20,000 RESIDENT RESEARCH GRANTS

Title: **Cross-Cultural Adaptation and Validation of the American Academy of Orthopaedic Surgeons Foot and Ankle Outcomes Questionnaire in Mexican-Americans**
Principal Investigator: **Ben S. Francisco, MD**
Co-Principal Investigator: **Boris Zelle, MD**
Grant Funded by: **OTA**

Title: **Covalently Linked Implant Coatings Containing Antibiotics and BMP-2 for Treatment of Open Fractures**
Principal Investigator: **Jared Alan Niska, MD**
Co-Principal Investigator: **Devon M. Jeffcoat, MD**
Grant Funded by: **FOT/OTA**

Title: **Covalent Targeting Project**
Principal Investigator: **Jose Manuel Mejia Oneto, MD, PhD**
Co-Principal Investigator: **Mark Lee, MD**
Grant Funded by: **FOT/OTA**

Title: **Fibrin Accumulation Stimulates Heterotopic Ossification**
Principal Investigator: **Megan E. Mignemi, MD**
Co-Principal Investigator: **William T. Obremsky, MD**
Grant Funded by: **FOT/OTA**

OTA 2013 RESEARCH GRANT AWARD RECIPIENTS

(June 1, 2013 - May 31, 2014 Grant Cycle)

$20,000 RESIDENT RESEARCH GRANTS

Title: **The Safety and Efficacy of Using Romiplostim for Bone Healing**
Principal Investigator: **Jonathan Scott Harris, MD**
Co-Principal Investigator: **Jeffrey O. Anglen, MD**
Grant Funded by: **FOT/OTA**

Title: **Fixation Compliance and BMP Response**
Principal Investigator: **Motasem I. Refaat, MD**
Co-Principal Investigator: **Mark A. Lee, MD**
Grant Funded by: **OTA**

Title: **The Dose-response Effect of the Mast Cell Stabilizer, Ketotifen Fumarate, on Post-traumatic Joint Contractures**
Principal Investigator: **Prism S. Schneider, MD, PhD**
Co-Principal Investigator: **Kevin Hildebrand, MD**
Grant Funded by: **OTA**

Title: **Assessing Knowledge Translation in Orthopaedic Surgery: A Time-series Analysis of Midshaft Clavicle Fracture Fixation in Ontario, Canada**
Principal Investigator: **Timothy Sean Leroux, MD**
Co-Principal Investigator: **Patrick David George Henry, MD, FRCSC**
Grant Funded by: **FOT/OTA**

Affiliate Meetings

Meeting Name (Contact)	Meeting Room	Day/Time
Gunshot Wounds Study Group (Jeffrey O. Anglen, MD)	*(Desert Suite V)*	Wednesday, 10/9: 7:00 am – 8:00 am
METRC – Research Coordinator Mtg (Cathy Epstein)	*(Desert Suite IV/VI)*	Wednesday, 10/9: 8:00 am – 5:00 pm
Pelvic & Acetabular Mtg (Paula Neal)	*(Pinnacle Peak 2)*	Wednesday, 10/9: 8:00 am – 6:00 pm
METRC – Research Coordinator Mtg (Cathy Epstein)	*(Desert Suite III)*	Wednesday, 10/9: 10:00 am – 4:00 pm
Geriatric Society (Fraser Cobb)	*(Pinnacle Peak 3)*	Wednesday, 10/9: Noon – 9:00 pm
Orthopaedic Trauma Research Consortium (Julie Agel, ATC)	*(Desert Suite VII)*	Thursday, 10/10: 7:00 am – 8:00 am
COTS (Kelly Trask)	*(Pinnacle Peak 2)*	Thursday, 10/10: 7:00 am – Noon
METRC Annual Meeting (Cathy Epstein)	*(Desert Suite IV & VI)*	Thursday, 10/10: 8:00 am – 11:00 am
FAITH Investigators Meeting (Julie Agel, ATC)	*(Desert Suite VIII)*	Thursday, 10/10: 11:30 am – 12:30 pm
FAITH-2 Introductory Meeting (Taryn Scott)	*(Wildflower Ballrm B)*	Friday, 10/11: 11:15 am to 12:30 pm
Scapula Study Group (Julie Agel, ATC)	*(Desert Suite VIII)*	Friday, 10/11: 11:30 am – 12:30 pm
HEALTH Research Coordinator Meeting (Kim Madden)	*(Wildflower Ballrm B)*	Friday, 10/11: 12:30 pm to 2:00 pm
Outpatient Surgery Centers as a Model for Improved Surgeon Efficiency and Economics in Orthopaedic Trauma: Surgcenter Development (Anthony Rhorer, MD)	*(Wildflower Ballrm B)*	Friday, 10/11: 5:30 pm – 7:30 pm

OTA GRATEFULLY ACKNOWLEDGES THE FOLLOWING EXHIBITORS FOR THEIR SUPPORT OF THE 29TH ANNUAL MEETING:

Booth #	Company Names	City, State
517	**Acumed**	Hillsboro, OR
103	**Advanced Arm Dynamics**	Redondo Beach, CA
91	**Advanced Biologics**	Carlsbad, CA
713	**Advanced Orthopaedic Solutions**	Torrance, CA
718	**AO Trauma North America**	Paoli, PA
213	**Arthrex Inc.**	Naples, FL
200	**BioAccess, Inc**	Baltimore, MD
806	**Biocomposites Inc.**	Wilmington, NC
705	**BioD**	Memphis, TN
300	**Biomet Trauma**	Warsaw, IN
94	**Bioventus LLC**	Durham, NC
312	**Bledsoe Brace Systems**	Grand Prairie, TX
92	**Bone Foam Inc.**	Plymouth, MN
203	**Brainlab**	Westchester, IL
90	**CFI Medical Solutions**	Fenton, MI
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816	**Delphi of TeamHealth**	Knoxville, TN
513	**Depuy Synthes Trauma**	West Chester, PA
703	**DeRoyal**	Powell, TN
107	**DGIMed Ortho Inc.**	Minnetonka, MN
205	**Ellipse Technologies Inc**	Irvine, CA
99	**Elsevier, Inc.**	Philadelphia, PA
717	**Enova Illumination**	St. Paul, MN
315	**Etex Corporation**	Cambridge, MA
701	**Harvest Technologies Corp**	Plymouth, MA
314	**I.T.S. USA**	Maitland, FL
716	**Illuminoss Medical Inc**	East Providence, RI
109	**Innomed Inc.**	Savannah, GA
313	**Innovision, Inc.**	Memphis, TN
208	**Invuity Inc**	San Francisco, CA
712	**Lilly USA, LLC.**	Indianapolis, IN

EXHIBITORS LISTING, continued

Booth #	Company Names	City, State
808	**Medartis**	Exton, PA
700	**Medtronic Spinal and Biologics**	Memphis, TN
101	**Microware Precision Co Ltd**	Logan, UT
207	**Mizuho OSI**	Union City, CA
306	**Olympus Biotech Corporation**	Hopkinton, MA
800	**Orthofix**	Lewisville, TX
309	**Orthopedics Today and Healio.Com By SLACK Incorporated**	Thorofare, NJ
719	**Orthoview**	Jacksonville, FL
709	**Pacific Instruments**	Honolulu, HI
707	**Pacira Pharmaceuticals**	Parsippany, NJ
708	**PFS Med, Inc**	Springfield, OR
204	**Planmed**	Roselle, IL
307	**Quintus Composites**	Camp Verde, AZ
812	**RTI Surgical, Inc.**	Alachua, FL
212	**Sawbones/Pacific Research Labs**	Vashon, WA
317	**Shanghai Bojin Electric Instruments**	Shanghai, China
804	**Skeletal Dynamics**	Miami, FL
202	**Skeletal Kinetics**	Cupertino, CA
404	**Smith & Nephew, Inc.**	Cordova, TN
318	**Sonoma Orthopedic Products, Inc.**	Santa Rosa, CA
89	**Starr Frame LLC**	Richardson, TX
501	**Stryker**	Mahwah, NJ
308	**Synergy Surgicalists**	Bozeman, MT
706	**Tornier OrthoHelix**	Medina, OH
319	**TriMed, Inc.**	Santa Clarita, CA
105	**Vivorte, Inc.**	Louisville, KY
98	**Wolters-Kluwer Health / Lippincott Williams & Wilkins Journal of Orthopaedic Trauma**	Philadelphia, PA
818	**Wound Care Technologies Inc.**	Chanhassen, MN
715	**Wright Medical Technology**	
412	**Zimmer**	Warsaw, IN
206	**Zyga Technology, Inc.**	Minnetonka, MN

Annual Guest Nation – China

The OTA is honored to welcome China as the 2013 Guest Nation. We are pleased to have the opportunity for collaboration with our Chinese colleagues, and a chance to recognize their contributions and achievements.

Representatives from the *Chinese Orthopaedic Trauma Society* will participate in a symposium at the International Orthopaedic Trauma Care Forum on Wednesday and will also speak Friday morning in the Annual Meeting general session about Chinese Trauma Education.

The Guest Nation program was initiated in 2011 in recognition of the importance and benefits of sharing knowledge and experience with international colleagues.

International Trauma Care Forum
(*Grand Sonoran F)*
Wednesday, October 9 – 7:30 am - 5:30 pm

Guest Nation Presentation
(*Grand Saguaro Ballroom)*
Wednesday, October 9 – 8:55 - 9:15 am
"International Comparison of Orthopaedic Post-Graduate Training: China"
Prof. Wang Manyi, MD,
Chinese Orthopaedic Association

OTA International Poster Reception
(*Grand Sonoran F)*
Wednesday, October 9 – 5:30 - 6:30 pm
All International Attendees Invited

2013 Basic Science Focus Forum

Wednesday, October 9, 2013

6:00 am **Speaker Ready Room**
(Grand Saguaro Foyer)

6:30 am **Registration**
(Grand Saguaro F)

Continental Breakfast
(Grand Sonoran Foyer)

7:25 am **Introduction** *(Grand Sonoran E)*
Theodore Miclau, III, MD, Program Chair

7:30 – 8:40 am

SYMPOSIUM 1: HOT TOPICS IN BIOMECHANICS: HIP FRACTURE FIXATION

(Notes p. 133) Moderators: *Steven A. Olson, MD*
Loren L. Latta, PE, PhD

7:30 am **Fixation Recommendations in 2013: Intramedullary Nailing**
Emil H. Schemitsch, MD

7:42 am **Fixation Recommendations in 2013: Plating**
Steven A. Olson, MD

7:54 am **Selecting the Best Model: Comparing Existing Devices to New Constructs**
Loren L. Latta, PE, PhD

8:06 am **Perspectives on the State of the Art - Where Are Improvements Needed?**
Thomas A. Russell, MD

8:18 am Discussion

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

See pages 91 - 132 for financial disclosure information.

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Basic Science Focus Forum – WEDNESDAY, OCTOBER 9, 2013

8:40 – 9:38 am

PAPER SESSION 1: BIOMECHANICALLY-DIRECTED FIXATION: HOT TOPICS

Moderators: *Steven A. Olson, MD*
Loren L. Latta, PE, PhD

8:40 am	**Overview** *Steven A. Olson, MD*
8:50 am (p. 134) PAPER #1	**Scapholunate and Lunotriquetral Ligament Injuries Associated With Distal Radius Fractures: The Effect of Wrist Position and Forearm Rotation During a Fall Onto an Outstretched Hand** ***Razvan Nicolescu, MD***[1]*; Elizabeth Anne Ouellette, MD, MBA*[2]*; Paul Clifford, MD*[1]*; Check C. Kam, MD*[3]*; Prasad J. Sawardeker, MD*[4]*; David N. Kaimrajh, MS*[5]*; Edward L. Milne, BS*[5]*; Jordan L. Fennema, MD*[6]*; Paul A. Diaz-Granados, MD*[7]*; Loren L. Latta, PE, PhD*[1,5]*;* [1]*University of Miami, Miami, Florida, USA;* [2]*Physicians for the Hand, Coral Gables, Florida, USA;* [3]*Indiana Hand to Shoulder Center, Indianapolis, Indiana, USA;* [4]*University of North Dakota, Fargo, North Dakota, USA;* [5]*Max Biedermann Institute for Biomechanics, Mt. Sinai, Miami Beach, Florida, USA;* [6]*University of Michigan, Ann Arbor, Michigan, USA;* [7]*University of Florida, Gainesville, Florida, USA*
8:56 am (p. 136) PAPER #2	**Biomechanical Analysis of Far Proximal Radial Shaft Fracture Fixation** *Gregory M. Gaski, MD*[1]*;* ***Stephen M. Quinnan, MD***[1]*; David Kaimrajh, MS*[2]*; Edward L. Milne, BS*[2]*; Loren L. Latta, PE, PhD*[1,2]*;* [1]*Department of Orthopaedics, University of Miami, Miami, Florida, USA;* [2]*Max Biedermann Institute for Biomechanics, Miami Beach, Florida, USA*
9:02 am (p. 138) PAPER #3	**No Difference in Fatigue Failure Between Nonlocked and Locked Interlocking Screws of Intramedullary Nails in Proximal Tibia Fractures** ***Utku Kandemir, MD****; Safa Herfat, PhD; Murat Pekmezci, MD;* *Department of Orthopaedic Surgery, University of California San Francisco, San Francisco, California, USA*
9:08 am	Discussion
9:14 am (p. 139) PAPER #4	**Is Overdrilling of Cortical Screws an Appropriate Surrogate for Osteoporosis in Biomechanical Testing?** ***Jacob L. Cartner, MS***[1]*; Megan Fessenden, MS*[1]*; Tim Petteys, MS*[1]*; Paul Tornetta, III, MD*[2]*;* [1]*Smith & Nephew, Memphis, Tennessee, USA;* [2]*Boston University Medical Center, Boston, Massachusetts, USA*

See pages 91 - 132 for financial disclosure information.

9:20 am
(p. 140)
PAPER #5

Finite Element Analysis of the Distal Femur: Fracture Motion Predicts Clinical Callus
William Lack, MD; *Jacob Elkins, MS; Trevor Lujan, PhD; Richard Peindl, PhD; James Kellam, MD; Donald Anderson, PhD; Thomas Brown, PhD; J. Lawrence Marsh, MD;*
University of Iowa, Iowa City, Iowa, USA

9:26 am
(p. 142)
PAPER #6

The Minimal Screw Length for Tricortical Syndesmosis Fixation in Ankle Fracture: A Cadaveric Study
Derrick O. Cote, MD[1]; *Alexander C.M. Chong, MSAE, MSME*[1,2]; *Bradley R. Dart, MD*[1]; *Nils Hakansson, PhD*[3]; *Michael Ward*[3]; *Pie Pichetsurnthorn*[3]; *Paul H. Wooley, PhD*[1,2];
[1]*Department of Surgery, Section of Orthopaedics, University of Kansas School of Medicine-Wichita, Wichita, Kansas, USA;*
[2]*Orthopedic Research Institute, Wichita, Kansas, USA;*
[3]*Bioengineering Program, Wichita State University, Wichita, Kansas, USA*

9:32 am — Discussion

9:38 am — Break

10:00 – 11:10 am

SYMPOSIUM 2: INFLAMMATION

(Notes p. 144) Moderators: *Peter V. Giannoudis, MD*
Chelsea Bahney, PhD

10:00 am — **Inflammation and Healing: When is Too Much a Bad Thing?**
Chelsea Bahney, PhD

10:10 am — **Inflammatory-Related Cytokines: What Role Do They Have in Healing?**
David J. Hak, MD, MBA

10:20 am — **Can PRPs Modulate the Inflammatory Response During Healing?**
Peter V. Giannoudis, MD

10:30 am — **Anti-Inflammatories: How and When Can They be Useful in Orthopaedic Trauma?**
David W. Sanders, MD

10:40 am — **Systemic Trauma: Evidence-Based Recommendations for Timing of Fixation in 2013**
Hans-Christopher Pape, MD

10:50 am — Discussion

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11:10 – 11:44 am	**PAPER SESSION 2: INFLAMMATION and BONE HEALING**
	Moderators: *Peter V. Giannoudis, MD* *Chelsea Bahney, PhD*
11:10 am	**Overview** *Peter V. Giannoudis, MD*
11:20 am (p. 145) PAPER #7	**Δ Age-Related Changes in Macrophage Polarization Affect Osteogenesis** *Fei Gao, MD, PhD;* ***Jesse A. Shantz, MD, MBA****; YanYiu Yu, PhD;* *Thedore Miclau, III, MD; Ralph S. Marcucio, PhD;* *San Francisco General Hospital, Orthopaedic Trauma Institute,* *San Francisco, California, USA*
11:26 am (p. 147) PAPER #8	**T-Lymphocyte Immune Modulation in Fracture Healing:** **The Role of IL-17F in a Novel GSK3/β-Catenin Independent Pathway** *Elaine Mau, MD, MSc[1]; Yufa Wang[1]; Heather Whetstone[2];* ***Diane Nam, Msc, MD, FRCSC[1]****;* *[1]Sunnybrook Health Sciences Center, Toronto, Ontario, Canada;* *[2]Hospital for Sick Children, Toronto, Ontario, Canada*
11:32 am (p. 148) PAPER #9	**Δ Lipopolysaccharide-Induced Systemic Inflammation Affects Bone Healing in a Murine Tibia Fracture Model** ***Jesse A. Shantz, MD, MBA****; Fei Gao, MD, PhD; Yan-Yiu Yu, PhD;* *Theodore Miclau III, MD; Ralph S. Marcucio, PhD;* *Department of Orthopaedic Surgery, University of California, San Francisco,* *San Francisco, California, USA*
11:38 am	Discussion
11:44 am 12:45 pm	Lunch

Δ OTA Grant

See pages 91 - 132 for financial disclosure information.

12:45 – 1:55 pm — SYMPOSIUM 3: BONE GRAFTING

(Notes p. 150)

Moderators: *Joseph Borrelli, Jr., MD*
Kenneth A. Egol, MD

12:45 pm **Efficacy of Autografts: Do Harvest Sites Matter?**
Aaron Nauth, MD

12:55 pm **Grafting in the Setting of Infection: Strategies**
Hans-Christoph Pape, MD

1:05 pm **Bone Graft Extenders: Which Ones Work?**
J. Tracy Watson, MD

1:15 pm **Bone Graft Timing: What is Most Optimal?**
Mark A. Lee, MD

1:25 pm **Bone Graft Substitutes: Is Anything as Effective as Autograft?**
Kenneth A. Egol, MD

1:35 pm Discussion

1:55 – 3:25 pm — PAPER SESSION 3: BONE REGENERATION and REPAIR

Moderators: *Joseph Borrelli, Jr., MD*
Kenneth A. Egol, MD

1:55 pm **Overview**
Joseph Borrelli, Jr., MD

2:05 pm (p. 151) PAPER #10
Δ The Influence of Construct Stiffness on Bone Regeneration in a Rodent Defect Model
Joel C. Williams, MD; *Matthew J. Anderson, MS; Blaine A. Christiansen, PhD; A. Hari Reddi, PhD; Mark A. Lee, MD;*
University of California Davis, Sacramento, California, USA

2:11 pm (p. 153) PAPER #11
Δ A Novel Rodent Critical-Sized Defect Model and BMP-7 Dose Response Study
Joel C. Williams, MD; *Sukanta Maitra, MD; Matthew J. Anderson, MS; Blaine A. Christiansen, PhD; A. Hari Reddi, PhD; Mark A. Lee, MD;*
University of California Davis, Sacramento, California, USA

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Basic Science Focus Forum – WEDNESDAY, OCTOBER 9, 2013

2:17 pm (p. 155) PAPER #12	**Spacer Composition Influences Properties of the Masquelet Membrane in Animals and the Observed Gene Expression Patterns of Inducible Membranes in Humans** ***Monique Bethel, MD***[1]; *Susan M. McDowell, MD*[1]; *Brahmananda R. Chitteti, PhD*[2]; *Tien-Min Gabriel Chu, DDS, PhD*[3]; *Janos Ertl, MD*[1]; *Brian H. Mullis, MD*[1]; *Melissa Kacena, PhD*[1]; *Jeffrey Anglen, MD*[1]; [1]*Department of Orthopaedic Surgery, Indiana University School of Medicine, Indianapolis, Indiana, USA;* [2]*Department of Internal Medicine, Division of Hematology and Oncology, Indiana University School of Medicine, Indianapolis, Indiana, USA;* [3]*Department of Restorative Dentistry, Indiana University School of Dentistry, Indianapolis, Indiana, USA*
2:23 pm (p. 156) PAPER #13	**The Masquelet Technique Induces the Formation of a Mesenchymal Stem Cell–Rich Periosteum-Like Membrane** *Richard J. Cuthbert*[1]; *Sarah Churchman*[1]; *Hiang-Boon Tan*[2]; *Dennis McGonagle*[1]; *Elena Jones*[1]; ***Peter V. Giannoudis, MD***[2] [1]*Division of Rheumatic and Musculoskeletal Disease, Leeds Institute of Molecular Medicine, University of Leeds, Leeds, United Kingdom* [2]*Academic Unit of Trauma and Orthopaedics, Leeds General Infirmary, Leeds, United Kingdom*
2:29 pm	Discussion
2:37 pm (p. 157) PAPER #14	**Opiates Impair Healing in Rat Femur Fracture Model** ***Jesse Chrastil, MD***; *Christopher Sampson, BS; Kevin B. Jones, MD; Thomas F. Higgins, MD;* *University of Utah, Salt Lake City, Utah, USA*
2:43 pm (p. 158) PAPER #15	**Systemic Inhibition of Notch Signaling Alters Multiple Phases of Fracture Healing** *Michael Dishowitz, PhD; Luke Lopas, BS; Joel Takacs, BS; Julie Engiles, VMD;* ***Jaimo Ahn, MD, PhD***; *Kurt Hankenson, DVM, PhD;* *University of Pennsylvania, Philadelphia, Pennsylvania, USA*
2:49 pm (p. 160) PAPER #16	**Unexpected Dispensable Role of MMP-9 in a Stabilized Femur Fracture Model** ***Cesar S. Molina, MD***; *Masato Yuasa, MD, PhD; Nicholas Mignemi, PhD; Jonathan G. Schoenecker, MD, PhD;* *Vanderbilt University Medical Center – Center for Bone Biology, Nashville, Tennessee, USA*
2:55 pm	Discussion
3:01 pm (p. 162) PAPER #17	**Δ The Nonessential and Potentially Pathogenic Role of a Fibrin Clot in Fracture Healing** *Masato Yuasa, MD; Nicholas Mignemi; Heather A. Cole; Lynda O' Rear; Jesse Bible, MD; William T. Obremskey, MD, MPH; Jeffry S. Nyman; Justin M. Cates; Herbert S. Schwartz;* ***Jonathan G. Schoenecker, MD, PhD***; *Vanderbilt University, Nashville, Tennessee, USA*

Δ OTA Grant

See pages 91 - 132 for financial disclosure information.

3:07 pm (p. 164) PAPER #18

Δ Single Nucleotide Polymorphisms in Osteogenic Genes in Atrophic Delayed Fracture Healing: A Preliminary Investigation

Vikram Sathyendra, MD; Henry J. Donahue, PhD; Kent E. Vrana, PhD; Arthur Berg, PhD; David Fryzel, BS; Jonathan Gandhi, BS; ***J. Spence Reid, MD****;*
Penn State University College of Medicine, Hershey, Pennsylvania, USA

3:13 pm (p. 166) PAPER #19

Systemic Proteomic Profiles Associated With Healing and Nonunion of Midshaft Femur Fractures

Andrew Ringnes, MD[1]*; Melissa Zimel, MD*[1]*; Denise Koueiter, MS*[1]*; Tristan Maerz, MS*[1]*; Timothy Geddes, BS*[2]*; Kevin Grant, MD*[1]*; Kevin C. Baker, PhD*[1]*;*
[1]*Department of Orthopaedic Surgery, Beaumont Health System, Royal Oak, Michigan, USA;*
[2]*Beaumont BioBank – Beaumont Health System, Royal Oak, Michigan, USA*

3:19 pm Discussion

3:25 pm Break

3:45 – 4:50 pm SYMPOSIUM 4: BUILDING NETWORKS: THE BASICS

(Notes p. 168) Moderators: *Saam Morshed, MD, PhD*
Paul Volberding, MD

3:45 pm	**Global Clinical Research: Why Do We Need It?**	*Paul Volberding, MD*
4:00 pm	**What Kind of Evidence is Needed to Change Practice or Policy?**	*David Shearer, MD, MPH*
4:10 pm	**Conducting International Clinical Research: What Resources are Necessary?**	*Emil H. Schemitsch, MD*
4:20 pm	**Selecting the Right Study Design: Balancing Science and Resources**	*Saam Morshed, MD, PhD*
4:30 pm	**International Research Studies: How to Partner?**	*Gerard P. Slobogean, MD, MPH*
4:40 pm	Discussion	

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4:50 – 5:30 pm

PAPER SESSION 4: INTERNATIONAL RESEARCH STUDIES

Moderators: *Saam Morshed, MD, PhD*
Paul Volberding, MD

4:50 pm	**International Registries: INORMUS** *Clary J. Foote, MD*
4:56 pm (p. 169) PAPER #20	**Management of Closed Femur Fractures with the SIGN Intramedullary Nail in Two Developing African Countries** ***Kyle R. Stephens, DO***[1]; *Daniel Galat, MD*[2]; *Duane Anderson, MD*[3]; *Kiprono G. Koech, MD*[2]; *Paul Whiting, MD*[4]; *Michael Mwachiro, MD*[2]; *Douglas W. Lundy, MD*[5]; [1]*Henry Ford Macomb Hospital, Clinton Township, Michigan, USA;* [2]*Tenwek Hospital, Bomet, Kenya;* [3]*Soddo Christian Hospital, Soddo, Ethiopia;* [4]*Tufts University, Boston, Massachusetts, USA;* [5]*Resurgens Orthopaedics, Marietta, Georgia, USA*
5:02 pm (p. 170) PAPER #21	**Δ The Design of a Prospective Observational Study to Evaluate the Outcomes of Operatively Treated Femoral Shaft Fractures in Sub-Saharan Africa** ***David Shearer, MD, MPH***[1]; *Edmund Eliezer, MD*[2]; *Billy Haonga, MD*[2]; *Saam Morshed, MD, PhD*[1]; [1]*University of California, San Francisco, California, USA;* [2]*Muhimbili Orthopaedic Institute, Dar es Salaam, Tanzania*
5:08 pm (Notes p. 171)	**International Randomized Control Trial: FLOW** *Kyle J. Jeray, MD*
5:14 pm	Discussion
5:30 pm	Adjourn to International Poster Reception

Δ OTA Grant

See pages 91 - 132 for financial disclosure information.

2013 Basic Science Focus Forum

Thursday, October 10, 2013

6:00 am	**Speaker Ready Room** *(Grand Saguaro Foyer)*
6:30 am	**Continental Breakfast** *(Grand Saguaro Foyer)*
7:25 am	**Introduction** *(Grand Sonoran E)* *Theodore Miclau, III, MD, Program Chair*

7:30 – 8:40 am

SYMPOSIUM 5: INFECTION

(Notes p. 172)	Moderators: *Emil H. Schemitsch, MD* *Joseph C. Wenke, PhD*
7:30 am	**Diagnosis of Infection in Orthopaedic Trauma Patients: New Technologies** *Joseph C. Wenke, PhD*
7:40 am	**Preventing Orthopaedic Infections** *David Markel, MD, MPH*
7:50 am	**Implant-Related Infections: Bugs and Biofilms** *Lawrence X. Webb, MD*
8:00 am	**Managing Hardware-Related Infections: Evidence Based Strategies** *Michael D. McKee, MD*
8:10 am	**Treatment of Post-Traumatic Osteomyelitis: The Next Generation!** *Todd O. McKinley, MD*
8:20 am	Discussion

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8:40 – 9:13 am

PAPER SESSION 5: MUSCULOSKELETAL INFECTION

Moderators: *Emil H. Schemitsch, MD*
Joseph C. Wenke, PhD

8:40 am	**Overview** *Emil H. Schemitsch, MD*
8:50 am (p. 173) PAPER #22	**Development and Evaluation of a Biofilm Dispersing Scaffold** *Carlos J. Sanchez Jr, PhD[1]; Edna M. Prieto, PhD[2,3]; **Chad A. Krueger, MD**[1]; Katarzyna J. Zienkiewicz, PhD[3]; Desiree R. Romano, BA[1]; Kevin S. Akers, MD[1]; S. K. Hardy[1], Ronald L. Woodbury[1], Scott A. Guelcher[2,3,4]; Joseph C. Wenke, PhD[1];* *[1]United States Army Institute of Surgical Research, Department of Extremity Trauma and Regenerative Medicine, Fort Sam Houston, San Antonio, Texas, USA;* *[2]Department of Chemical and Biomolecular Engineering, Vanderbilt University, Nashville, Tennessee, USA;* *[3]Center for Bone Biology, Vanderbilt University Medical Center, Nashville, Tennessee, USA;* *[4]Department of Biomedical Engineering, Vanderbilt University, Nashville, Tennessee, USA*
8:56 am (p. 175) PAPER #23	**Intraoperative Dip-coating Inhibits Biofilms and Supports Bone Healing During Infection** ***Thomas P. Schaer, DO**; Suzanne Stewart, DVM;* *University of Pennsylvania School of Veterinary Medicine, Kennett Square, Pennsylvania, USA*
9:02 am (p. 177) PAPER #24	**Evaluation of an Absorbable Gentamicin-Eluting Plate Sleeve in an Ovine Fracture Healing Model** ***Joanne Haughan, DVM**[1]; C. Alex DePaula, PhD[2]; David Armbruster, BS[2]; Thomas P. Schaer, DO[1];* *[1]University of Pennsylvania School of Veterinary Medicine, Kennett Square, Pennsylvania, USA;* *[2]DePuy Synthes - Biomaterials, West Chester, Pennsylvania, USA*
9:08 am	Discussion
9:13 am	Break

See pages 91 - 132 for financial disclosure information.

9:30 – 10:40 am	SYMPOSIUM 6: STEM CELL THERAPIES

(Notes p. 179) Moderators: *Theodore Miclau, III, MD*
Ralph S. Marcucio, PhD

9:30 am **Stem Cell Populations: Which Ones are Most Useful?**
Aaron Nauth, MD

9:40 am **Stem Cells: How Do They Influence Healing?**
Peter V. Giannoudis, MD

9:50 am **Progenitor Cells: What are the Sources?**
Ralph S. Marcucio, MD

10:00 am **Stem Cell Therapies: What Still Needs to be Overcome?**
Chelsea Bahney, PhD

10:10 am **Developing Stem Cell Approaches to Bone Defect**
George F. Muschler, MD

10:20 am Discussion

10:40 – 11:14 am	PAPER SESSION 6: STEM CELLS

Moderators: *Theodore Miclau, III, MD*
Ralph S. Marcucio, PhD

10:40 am **Overview**
Ralph S. Marcucio, PhD

10:50 am **Δ Effects of Endothelial Progenitor Cell Therapy on Diabetic Rat Fracture Healing**
(p. 180)
PAPER #25
Clifford Lin, MD; *Aaron Nauth, MD, FRCSC; Emil H. Schemitsch, MD, FRCSC; University of Toronto, St. Michael's Hospital, Toronto, Ontario, Canada*

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Basic Science Focus Forum – THURSDAY, OCTOBER 10, 2013

10:56 am
(p. 181)
PAPER #26

The Effects of Aminobisphosphonate In Vitro and In Vivo Treatment on the Osteogenic Capacity of Bone Marrow Stromal Cells from Senile Osteoporotic Hip Fracture Patients

Richard A. Lindtner, MD[1]; *André N. Tiaden, PhD*[2]; *Konstantin Genelin, MD*[1]; *Hannes L. Ebner, PhD*[1]; *Ingrid Sitte, MD*[1]; *Marina Klawitter*[2]; *Prof. Brigitte von Rechenberg, DVM*[2]; *Prof. Michael Blauth, MD*[1]; *Peter J. Richards, PhD*[2];
[1]Department for Trauma Surgery and Sports Medicine, Medical University of Innsbruck, Innsbruck, Austria;
[2]Bone and Stem Cell Research Group, Competence Center for Applied Biotechnology and Molecular Medicine, University of Zurich, Zurich, Switzerland

11:02 am
(p. 182)
PAPER #27

Healing Segmental Bone Defects With Endothelial Progenitor Cell Subtypes

Erica Giles, BS[1]; *Michael Glick, BSc*[1]; *Tony Lin, BSc*[1]; *Wendy Chi*[1]; *Aaron Nauth, MD*[1,2]; *Emil H. Schemitsch, MD*[1,2];
[1]Musculoskeletal Laboratory, St. Michael's Hospital, Toronto, Ontario, Canada;
[2]Department of Surgery, Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada

11:08 am — Discussion

11:14 am — **Adjourn to Industry Lunch Symposia**
(Grand Sonoran A-D)

ORTHOPAEDIC TRAUMA ASSOCIATION

2013 Annual Meeting

Thursday, October 10, 2013

6:00 am	**Speaker Ready Room** *(Grand Saguaro Foyer)*
6:15 am	**Registration** *(Grand Saguaro Foyer)*
11:00 am- 12:45 pm	**INDUSTRY SYMPOSIA** (on-site registration available) *(Lunch Included) (Grand Sonoran A-D)*
1:00 pm	**Welcome and Industry Donor Awards** *(Grand Saguaro Ballroom)* *Andrew H. Schmidt, MD – OTA President* *Thomas F. Higgins, MD – Program Chair* *Robert V. O'Toole, MD – Program Co-Chair* *Laura J. Prokuski, MD – Local Host*

1:20 – 2:50 pm SYMPOSIUM I: EVALUATING OUTCOMES IN THE 21st CENTURY

(Notes p. 185) **Moderator:** *Mark S. Vrahas, MD* *(Grand Saguaro Ballroom)*
Faculty: *Richard C. Gershon, PhD* *Nan Rothrock, PhD*
Thomas F. Higgins, MD

1:20 pm	**History, Organization, and Status of NIH PROMIS Initiative** *Nan Rothrock, PhD*
1:35 pm	Questions and Discussion
1:45 pm	**Introduction to Item Response Theory and Computer Adaptive Testing** *Richard C. Gershon, PhD*
2:05 pm	Questions and Discussion
2:15 pm	**Introduction to Assessment Center - Research Tool for PROMIS Instruments** *Nan Rothrock, PhD*
2:25 pm	Questions and Discussion
2:30 pm	**Early Experience Using PROMIS Tools with Orthopaedic Patients** *Thomas F. Higgins, MD*
2:45 pm	Questions and Discussion

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

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2:50 pm	Refreshment Break *(Grand Canyon Ballroom)* Visit Scientific Posters *(Grand Saguaro Foyer)* & Technical Exhibits *(Grand Canyon Ballroom)*

(Grand Saguaro Ballroom)

SCIENTIFIC PAPER SESSION I
POLYTRAUMA / PELVIS / POST-TRAUMATIC RECONSTRUCTION

3:20 – 4:46 pm

Moderators - Pierre Guy, MD, MBA & H. Claude Sagi, MD

3:20 pm (p. 186) PAPER #28	**Time to Definitive Operative Treatment Following Open Fracture Does Not Impact Development of Deep Infection: A Prospective Cohort Study of 736 Subjects** ***Donald Weber, MD***[1]*; Sukhdeep K. Dulai, MD, MSc, FRCS(C)*[1]*;* *Joseph Bergman, MD*[1]*; Richard E. Buckley, MD*[2]*; Lauren A. Beaupre*[1]*;* [1]*University of Alberta, Edmonton, Alberta, Canada;* [2]*University of Calgary, Calgary, Alberta, Canada*
3:26 pm (p. 188) PAPER #29	**Pain and PTSD Following Major Extremity Trauma: Results from the METALS Study** ***Renan C. Castillo, PhD****; Anthony R. Carlini, MS; Ellen J. MacKenzie, PhD;* *for the METALS Study Group;* *Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA*
3:32 pm (p. 190) PAPER #30	**The Effectiveness of an Osseointegrated Prosthesis Compared With Socket Prosthesis After Transfemoral Amputation** *Henk van de Meent, MD, PhD; Maria Hopman, PhD;* ***Jan Paul M. Frölke, MD, PhD****;* *Radboud University Nijmegen Medical Center, Nijmegen, The Netherlands*
3:38 pm	Discussion
3:43 pm (p. 191) PAPER #31	**Multiple Orthopaedic Procedures in the Initial Surgical Setting: When Do the Benefits Outweigh the Risks in Patients With Multiple System Trauma?** ***Benjamin R. Childs, BS****; Nickolas J. Nahm, MD; Timothy A. Moore, MD;* *Heather A. Vallier, MD;* *MetroHealth Medical Center, Cleveland, Ohio, USA*
3:49 pm (p. 193) PAPER #32	**Early Appropriate Care: A Protocol to Standardize Resuscitation Assessment and to Expedite Fracture Care Reduces Hospital Stay and Enhances Revenue** ***Heather A. Vallier, MD****; Andrea Dolenc, BS; Timothy A. Moore, MD;* *MetroHealth Medical Center, Cleveland, Ohio, USA*
3:55 pm	Discussion

See pages 91 - 132 for financial disclosure information.

4:00 pm
(p. 195)
PAPER #33

The Effect of Surgical Treatment on Mortality After Acetabular Fracture in the Elderly: A Multicenter Study of 454 Patients

Joshua L. Gary, MD[1]; *Ebrahim Paryavi, MD, MPH*[2]; *Steven D. Gibbons*[3]; *Michael J. Weaver, MD*[4]; *Jordan H. Morgan, BS*[4]; *Scott P. Ryan*[5], *Adam J. Starr, MD*[3]; *Robert V. O'Toole, MD*[2];
[1]*University of Texas Health Science Center, Houston, Texas, USA;*
[2]*University of Maryland School of Medicine, Baltimore, Maryland, USA;*
[3]*University of Texas Southwestern Medical Center, Dallas, Texas, USA;*
[4]*Brigham and Women's Hospital & Massachusetts General Hospital, Boston, Massachusetts, USA;*
[5]*Tufts Medical Center, Boston, Massachusetts, USA*

4:06 pm
(p. 196)
PAPER #34

Acute Total Hip Arthroplasty Versus Open Reduction and Internal Fixation for Acetabular Fractures Involving the Posterior Wall in Patients <65 Years Old: A Matched Cohort Analysis

Carol A. Lin, MD, MA; *Jerald Westberg, BA; Andrew H. Schmidt, MD;*
Hennepin County Medical Center, Minneapolis, Minnesota, USA

4:12 pm
(p. 197)
PAPER #35

Patient-Reported Health After Surgically Treated Displaced Sacral Fractures: A 10-Year Follow-up

Aron Adelved, MD[1,2]; *Anna Tötterman, MD, PhD*[3]; *Thomas Glott, MD*[4]; *Helene Søberg, PT, PhD*[5]; *Jan Erik Madsen, MD, PhD*[2]; *Olav Røise, MD, PhD*[2];
[1]*Orthopaedic Department, Akershus University Hospital, Lørenskog, Norway;*
[2]*Orthopaedic Department, Oslo University Hospital, Olso, Norway;*
[3]*Orthopaedic Department, Karolinska University Hospital, Stockholm, Sweden;*
[4]*Department for Spinal Cord Injury and Multitrauma, Sunnaas Hospital, Nesodden, Norway;*
[5]*Department of Physical Medicine and Rehabilitation, Oslo University Hospital, Oslo, Norway*

4:18 pm

Discussion

4:23 pm
(p. 198)
PAPER #36

•Recombinant Human Morphogenetic Protein-2 (rhBMP-2) Versus Iliac Crest Autograft to Treat Tibia Nonunion: A Retrospective Multicenter Study

Southeast Fracture Consortium; ***William T. Obremskey, MD, MPH***;
Vanderbilt University Medical Center, Nashville, Tennessee, USA

4:29 pm
(p. 199)
PAPER #37

The Reamer Irrigator Aspirator (RIA) as a Device for Harvesting Bone Graft Compared With Iliac Crest Bone Graft: Union Rates and Complications

Peter J. Nowotarski, MD; ***John Dawson, MD***; *Dirk Kiner, MD; Warren Gardner, II, MD; Rachel Swafford, MS;*
University of Tennessee College of Medicine – Chattanooga, Chattanooga, Tennessee, USA

• 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 496.

4:35 pm
(p. 200)
PAPER #38

Dynamizations and Exchange Nailing: Success Rates and Indications

Jody Litrenta, MD[1]; *Paul Tornetta, III, MD*[1]; *Cory A. Collinge, MD*[2]; *Heather A. Vallier, MD*[3]; *Clifford B. Jones, MD*[4]; *Christiane G. Kruppa, MD*[4]; *Reza Firoozabadi, MD*[5]; *Kenneth A. Egol, MD*[6]; *Ross K. Leighton, MD*[7]; *Mohit Bhandari, MD*[8]; *Emil H. Schemitsch, MD*[9]; *David W. Sanders, MD*[10];
[1]*Boston University Medical Center, Boston, Massachusetts, USA;*
[2]*Texas Health, Fort Worth, Texas, USA;*
[3]*MetroHealth Medical Center, Cleveland, Ohio, USA;*
[4]*Orthopaedic Associates of Michigan, Grand Rapids, Michigan, USA;*
[5]*University of Washington, Seattle, Washington, USA;*
[6]*NYU – Hospital for Joint Diseases, New York, New York, USA;*
[7]*Dalhousie University, Halifax, Nova Scotia, Canada;*
[8]*McMaster University, Hamilton, Ontario, Canada;*
[9]*St. Michael's Hospital, Toronto, Ontario, Canada;*
[10]*London Health Science Centre, London, Ontario, Canada*

4:41 pm — Discussion

4:46 – 5:16 pm
(Notes p. 202)

President's Message

(General Session Room - Grand Saguaro Ballroom)

Andrew H. Schmidt, MD

"Standardization and Systems: Steps We Must Take (Together)"

Introduced by
Thomas F. Higgins, MD

5:16 pm – 6:16 pm

OTA BUSINESS MEETING
OTA Members Only *(General Session Room - Grand Saguaro Ballroom)*

6:30 pm – 8:30 pm

WELCOME RECEPTION and OTA RESEARCH FUNDRAISING AUCTION

Join the OTA for cocktails and a generous assortment of hors d'oeuvres Ballroom Lawn at the JW Marriott.

See pages 91 - 132 for financial disclosure information.

ORTHOPAEDIC TRAUMA ASSOCIATION

2013 Annual Meeting

Friday, October 11, 2013

6:00 am	**Speaker Ready Room** *(Grand Saguaro Foyer)*
6:15 am	**Registration** *(Grand Saguaro Foyer)* **Attendee Registration** *(Grand Saguaro Foyer)*
6:30 am	**Scientific Posters** (Technical Exhibits Open at 9:00 am) *(Grand Saguaro Foyer)* **Continental Breakfast** *(Grand Saguaro Foyer)*
6:30 - 7:45 am (Notes p. 203 - 204)	**Concurrent Breakout Sessions** Case Presentations Skills Labs Poster Tour

6:30 – 7:45 am **CASE PRESENTATIONS** ***No Tickets Required***

Orthopaedic Trauma Coding *(Pinnacle Peak 1)*
Moderator: *J. Scott Broderick, MD*
Faculty: *William R. Creevy, MD* and *M. Bradford Henley, MD*

The Challenging Hip Fracture: Pearls and Pitfalls *(Pinnacle Peak 2)*
Moderator: *Amer J. Mirza, MD*
Faculty: *Darin Freiss, MD; Erik Kubiak, MD* and *Edward A. Perez, MD*

Proximal Humerus ORIF – Advances in Fixation and Augmentation *(Pinnacle Peak 3)*
Moderator: *Clifford B. Jones, MD*
Faculty: *Michael J. Gardner, MD* and *Samir Mehta, MD*

2 Minutes / 2 Slides: Ankle Injuries Technical Tips and Tricks *(Wildflower Ballroom A)*
Moderator: *Pierre Guy, MD, MBA*
Faculty: *Kenneth A. Egol, MD; David W. Sanders, MD; Paul Tornetta, III, MD* and *Timothy O. White, MD*

Distal Humerus Fractures: Tips and Tricks *(Wildflower Ballroom B)*
Moderator: *Utku Kandemir, MD*
Faculty: *John T. Gorczyca, MD; Michael D. McKee, MD* and *Milan K. Sen, MD*

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6:30 – 7:45 am	SKILLS LABS	*Tickets Required*

Fixation of Clavicle Fractures *(#SL1)* *(Grand Sonoran A-B)*
Lab Leader: *Gregory M. Osgood, MD*
Faculty: *Daren P. Forward, MD; Erik A. Hasenboehler, MD; CDR Joseph E. Strauss, DO* and *David B. Weiss, MD*

ORIF Distal Tibia and Fibula Fractures *(#SL2)* *(Grand Sonoran C-D)*
Lab Leader: *Matt L. Graves, MD*
Faculty: *David P. Barei, MD, FRCSC; Patrick F. Bergin, MD; Jason W. Nascone, MD; Timothy G. Weber, MD* and *Bradley J. Yoo, MD*

7:00 – 7:45 am	GUIDED POSTER TOUR	*Tickets Required*

Foot / Ankle / Pilon *(#P1)* *(Grand Saguaro Foyer)*
Guide: *Clifford B. Jones, MD*

(Grand Saguaro Ballroom)

SCIENTIFIC PAPER SESSION II
GERIATRIC

8:00 – 8:55 am

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

8:00 am
(p. 205)
PAPER #39

Association Between Type of Surgery and Perioperative Acute Myocardial Infarction in Elderly Hip Fracture Patients

Nathalie H. Urrunaga, MD, MS[1]; *Amelia C. Watkins, MD*[2]; *Robert S. Sterling, MD*[3]; *Mary L. Forte, PhD, DC*[4];
[1]Department of Medicine, Division of Gastroenterology and Hepatology, University of Maryland School of Medicine, Baltimore, Maryland, USA;
[2]Department of Surgery, University of Maryland School of Medicine, Baltimore, Maryland, USA;
[3]Department of Orthopaedics, University of Maryland School of Medicine, Baltimore, Maryland, USA;
[4]Departments of Epidemiology and Orthopaedics, University of Maryland School of Medicine, Baltimore, Maryland, USA

See pages 91 - 132 for financial disclosure information.

8:06 am (p. 207) PAPER #40	**Effect of Vitamin K on Surgical Timing After Hip Fracture in Patients on Warfarin** ***Jacob Lantry, MD***; *John T. Gorczyca, MD;* *University of Rochester Medical Center, Rochester, New York, USA*
8:12 am (p. 208) PAPER #41	**Healing Time and Complications in Surgically Treated Atypical Femur Fractures Associated With Bisphosphonate Use: A Multicenter Series** ***Yelena Bogdan, MD***[1]; *Paul Tornetta, III, MD[1]; Thomas A. Einhorn, MD[1]; Pierre Guy, MD[2]; Lise Leveille, MD[2]; Juan Robinson, MD[3]; Nikkole Haines, MD[4]; Daniel S. Horwitz, MD[5]; Clifford B. Jones, MD[6]; Emil H. Schemitsch, MD[7]; H. Claude Sagi, MD[8]; Daniel Stahl, MD[9]; Megan Brady, MD[10]; David W. Sanders, MD[11]; Thomas G. Higgins, MD[12]; Michael Kain, MD[13]; Cory A. Collinge, MD[14]; Stephen A. Kottmeier, MD[15]; Darin Freiss, MD[16];* *[1]Boston University Medical Center, Boston, Massachusetts, USA;* *[2]University of British Columbia, Vancouver, British Columbia, Canada* *[3]Dalhousie University, Halifax, Nova Scotia, Canada;* *[4]Carolinas Medical Center, Charlotte, North Carolina, USA;* *[5]Geisinger, Danville, Pennsylvania, USA;* *[6]Orthopaedic Associates of Michigan, Grand Rapids, Michigan, USA;* *[7]St. Michael's Hospital, Toronto, Ontario, Canada;* *[8]Tampa General Hospital, Tampa, Florida, USA;* *[9]Scott & White Hospital, Temple, Texas, USA;* *[10]MetroHealth Medical Center, Cleveland, Ohio, USA;* *[11]London Health Sciences Centre, London, Ontario, Canada;* *[12]University of Utah, Salt Lake City, Utah, USA;* *[13]Lahey Clinic, Burlington, Massachusetts, USA;* *[14]Fort Worth, Texas, USA;* *[15]Stony Brook University, Stony Brook, New York, USA;* *[16]Oregon Health & Science University, Portland, Oregon, USA*
8:18 am	Discussion
8:23 am (p. 210) PAPER #42	**Rehospitalization After Surgically Treated Hip Fractures: Targets for Intervention** ***Christopher M. McAndrew, MD***; *Michael J. Gardner, MD; Ellen F. Binder, MD; William M. Ricci, MD; Eric J. Lenze, MD;* *Washington University School of Medicine, St. Louis, Missouri, USA*
8:29 am (p. 211) PAPER #43	**Can an Evidence-Based Treatment Algorithm for Intertrochanteric Hip Fractures Maintain Quality at a Reduced Cost?** ***Kenneth A. Egol, MD***; *Alejandro I. Marcano, MD; Lambert Lewis, BS; Nirmal C. Tejwani, MD; Toni M. McLaurin, MD; Roy I. Davidovitch, MD;* *NYU Hospital for Joint Diseases, New York, New York, USA*
8:35 am (p. 212) PAPER #44	**Δ Intramedullary Versus Extramedullary Fixation of Unstable Intertrochanteric Hip Fractures: A Prospective Randomized Control Study** ***Rudolf Reindl, MD, FRCSC***; *Edward J. Harvey, MD, FRCSC; Gregory K. Berry, MD, FRCSC; Canadian Orthopaedic Trauma Society (COTS);* *McGill University Health Centre, Montreal, Canada*

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8:41 am
(p. 213)
PAPER #45

Is Immediate Weight Bearing Safe for Periprosthetic Distal Femur Fractures Treated With Locked Plating?
Wade R. Smith, MD; *Jason W. Stoneback, MD; Steven J. Morgan, MD; University of Colorado School of Medicine, Aurora, Colorado, USA*

8:47 am Discussion

8:55 am – 9:15 am
(Notes p. 214)

Guest Nation – China

The OTA is honored to welcome China as the 2013 Guest Nation. We are pleased to have the opportunity for collaboration with our Chinese colleagues, and a chance to recognize their contributions and achievements.

8:55 am **Guest Nation Introduction**
Andrew H. Schmidt, MD

8:59 am **Best International Forum Paper:**
TBD

9:07 am **Guest Nation Presentation**
Prof. Wang Manyi, MD – Chinese Orthopaedic Association
"International Comparison of Orthopaedic Post-Graduate Training: China"

9:15 am – 9:45 am
(Notes p. 215)

John Border Memorial Lecture

(General Session Room - Grand Saguaro Ballroom)

Skeletal Trauma: Global Conundrum

Bruce D. Browner, MD
Professor and Chairman Emeritus
New England Musculoskeletal Institute
University of Connecticut Health Center
Farmington, Connecticut, USA

Introduction: Andrew H. Schmidt, MD

9:45 am – 10:15 am
Refreshment Break *(Grand Canyon Ballroom)*
Visit Scientific Posters *(Grand Saguaro Foyer)*
& Technical Exhibits *(Grand Canyon Ballroom)*

See pages 91 - 132 for financial disclosure information.

10:15 - 11:45 am (Notes p. 216)	**Concurrent Sessions** ***(Mini Symposia and Scientific Session run concurrently.)*** Mini Symposia Scientific Paper Session III: Hip / Femur

10:15 – 11:45 am **MINI SYMPOSIA** *No Tickets Required*

How to Use the OTA Case Database at Your Institution *(Pinnacle Peak 1)*
Moderator: *Julie Agel, ATC*

Femoral Neck Fractures in Young Adults: Why Are We Not "Fixing" These Better? *(Pinnacle Peak 2)*
Moderator: *Cory A. Collinge, MD*
Faculty: *Michael T. Archdeacon, MD; Frank Liporace, MD* and *Bradley R. Merk, MD*

Traumatic Limb Injuries Requiring Amputation: A Multidisciplinary Approach Using the Osteomyoplastic (Ertl) Technique *(Pinnacle Peak 3)*
Moderator: *William J. Ertl, MD*
Faculty: *Jonathan D. Day, CPO; Carol P. Dionne, PT, DPT, PhD, OCS; Janos P. Ertl, MD* and *James R. Ficke, MD*

(Grand Saguaro Ballroom)

SCIENTIFIC PAPER SESSION III
HIP / FEMUR

10:15 – 11:24 am **Moderators - John T. Ruth, MD & Thomas A. DeCoster, MD**

10:15 am (p. 217) PAPER #46	**Δ A Prospective Randomized Trial Investigating the Effect of the Reamer-Irrigator-Aspirator (RIA) on the Volume of Embolic Load and Respiratory Functions During Intramedullary Nailing of Femoral Shaft Fractures** *Jeremy A. Hall, FRCSC; Michael D. McKee, MD;* ***Milena R. Vicente, RN;*** *Zachary A. Morison; Niloofar Dehghan; Hans J. Kreder, MD; Brad Petrisor, MD; Emil H. Schemitsch, MD;* *St. Michael's Hospital, University of Toronto, Toronto, Ontario, Canada*
10:21 am (p. 219) PAPER #47	**Morbid Obesity Increases the Risk of Systemic Complications in Patients With Femoral Shaft Fractures** ***Stuart Deaderick, BS****; Robert F. Murphy, MD; John C. Weinlein, MD;* *University of Tennessee – Campbell Clinic, Memphis, Tennessee, USA*

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FRIDAY, OCTOBER 11, 2013

10:27 am
(p. 220)
PAPER #48

Operative Versus Nonoperative Treatment of Femoral Fractures in Spinal Cord Injury Patients

Julius A. Bishop, MD[1]; *Paola A. Suarez, MPH*[2]; *Lisa A. DiPonio, MD*[3]; *Doug Ota, MD, PhD*[1,4]; *Catherine M. Curtin, MD*[5,6];
[1]*Department of Orthopaedic Surgery, Stanford University, Palo Alto, California, USA;*
[2]*Center for Health Care Evaluation, Department of Veterans Affairs (VA), Menlo Park, California, USA;*
[3]*Department of PM&R, VA Ann Arbor Healthcare System, Ann Arbor, Michigan, USA;*
[4]*Spinal Cord Injury Service, VA Health Care System, Palo Alto, California, USA;*
[5]*Rehabilitation Research and Development, VA Health Care System, Palo Alto, California, USA;*
[6]*Division of Plastic Surgery, Stanford University, Palo Alto, California, USA*

10:33 am Discussion

10:38 am
(p. 221)
PAPER #49

Δ Locked Plating Versus Retrograde Nailing for Distal Femur Fractures: A Multicenter Randomized Trial

Paul Tornetta, III, MD[1]; *Kenneth A. Egol, MD*[2]; *Clifford B. Jones, MD*[3]; *Janos P. Ertl, MD*[4]; *Brian Mullis, MD*[4]; *Edward Perez, MD*[5]; *Cory A. Collinge, MD*[6]; *Robert Ostrum, MD*[7]; *Catherine Humphrey, MD*[8]; *Sean Nork, MD*[9]; *Michael J. Gardner, MD*[10]; *William M. Ricci, MD*[10]; *Laura S. Phieffer, MD*[11]; *David Teague, MD*[12]; *William Ertl, MD*[12]; *Christopher T. Born, MD*[13]; *Alan Zonno, MD*[13]; *Judith Siegel, MD*[14]; *H. Claude Sagi, MD*[15]; *Andrew Pollak, MD*[16]; *Andrew H. Schmidt, MD*[17]; *David Templeman, MD*[17]; *Andrew Sems, MD*[18]; *Darin M. Freiss, MD*[19]; *Hans-Christoph Pape, MD*[20];
[1]*Boston University Medical Center, Boston, Massachusetts, USA;*
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[4]*Indiana University, Indianapolis, Indiana, USA;*
[5]*Campbell Clinic, Memphis, Tennessee, USA;*
[6]*Orthopedic Specialty Associates, Fort Worth, Texas, USA;*
[7]*Cooper University Hospital, Camden, New Jersey, USA;*
[8]*University of Rochester, Rochester, New York, USA;*
[9]*Harborview Medical Center, Seattle, Washington, USA;*
[10]*Barnes-Jewish Hospital, St. Louis, Missouri, USA;*
[11]*Ohio State University, Columbus, Ohio, USA;*
[12]*University of Oklahoma, Oklahoma City, Oklahoma, USA;*
[13]*Brown University, Providence, Rhode Island, USA;*
[14]*UMass Medical Center, Worcester, Massachusetts, USA;*
[15]*Tampa General Hospital, Tampa, Florida, USA;*
[16]*University of Maryland – Shock Trauma, Baltimore, Maryland, USA;*
[17]*Hennepin County Medical Center, Minneapolis, Minnesota, USA;*
[18]*St. Mary's Hospital - Mayo Clinic, Rochester, Minnesota, USA;*
[19]*Oregon Health & Science University, Portland, Oregon, USA;*
[20]*University of Pittsburgh, Pittsburgh, Pennsylvania, USA*

Δ OTA Grant

See pages 91 - 132 for financial disclosure information.

10:44 am
(p. 223)
PAPER #50

Distal Locking in Femoral and Tibial Nailing of 265 Patients Without X-Ray Guidance: A Multicenter Study

Ramon B. Gustilo, MD[1]; *Arturo C. Canete, MD*[2]; *Godofredo V. Dungca III, MD*[3]; *Regidor B. De Leon, III, MD*[4]; *Daniel V. Dungca, MD*[5]; *Jereme B. Atupan, MD*[6]; *Joaquin C. Pandanan, MD*[7]; *Wilfredo B. Pacheco, MD*[6]; *Abigail T. Jao, BS, MEM-BME*[8];
[1]*Philippine Orthopedic Institute, Makati City, Philippines;*
[2]*Philippine Orthopedic Center, Quezon City, Philippines;*
[3]*Tarlac Provincial Hospital, Tarlac City, Philippines;*
[4]*East Avenue Medical Center, Quezon City, Philippines;*
[5]*Jose Reyes Memorial Medical Center, Manila, Philippines;*
[6]*University of the Philippines, Philippine General Hospital, Manila, Philippines;*
[7]*De La Salle University Medical Center, Dasmarinas City, Philippines;*
[8]*De La Salle University, Pasay City, Philippines*

10:50 am
(p. 224)
PAPER #51

A Prospective Randomized Control Trial of Fixation of Intertrochanteric Fractures: Compression Hip Screw Versus Third Generation Long Cephalomedullary Nail

Cameron Cooke, MD; *Diana Kennedy, MBBS; Doug King, FRACS (ortho); Mark Dekkers, FRACS (ortho);*
Princess Alexandra Hospital, Brisbane, Queensland, Australia

10:56 am Discussion

11:01 am
(p. 225)
PAPER #52

Femoral Neck Shortening Impairs Gait Pattern and Muscle Strength After Internal Fixation of a Femoral Neck Fracture

Stephanie M. Zielinski, MD[1]; *Noël L.W. Keijsers*[2]; *Stephan F.E. Praet*[3]; *Martin J. Heetveld*[4]; *Mohit Bhandari, MD, PhD, FRCSC*[5]; *Jean Pierre Wilssens*[6]; *Peter Patka*[7]; *Esther M.M. Van Lieshout*[1]; *on behalf of the FAITH trial investigators;*
[1] *Department of Surgery-Traumatology, Erasmus MC, University Medical Center Rotterdam, Rotterdam, The Netherlands;*
[2]*Department of Research, Development and Education, Sint Maartenskliniek, Nijmegen, The Netherlands;*
[3]*Department of Rehabilitation Medicine & Physical Therapy, Erasmus MC, University Medical Center Rotterdam, Rotterdam, The Netherlands;*
[4]*Department of Surgery, Kennemer Gasthuis, Haarlem, The Netherlands;*
[5]*Department of Clinical Epidemiology and Biostatistics, McMaster University, Hamilton, Ontario, Canada;*
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11:07 am
(p. 227)
PAPER #53

Implication of Subgrouping in Valgus Femoral Neck Fractures: Comparison of 31-B1.1 With 31-B1.2 Fracture in OTA Classification

Kyu Hyun Yang, MD[1]; *Hyung Keun Song, MD*[2]; *Hyun Cheol Oh, MD*[3]; *You Gun Won, MD*[1];
[1]*Department of Orthopaedic Surgery, Gangnam Severance Hospital, Yonsei University, Seoul, Korea;*
[2]*Ajou University Hospital, Suwon, Korea;*
[3]*National Health Insurance Corporation Hospital, Goyang, Korea*

11:13 am
(p. 228)
PAPER #54

•Fixation of Displaced Femoral Neck Fractures in Young Adults: Fixed-Angle Devices or Pauwel Screws?

C. Max Hoshino, MD; *Matthew W. Christian, MD; Robert V. O'Toole, MD; Theodore T. Manson, MD;*
Department of Orthopaedic Surgery, R Adams Cowley Shock Trauma Center, Baltimore, Maryland, USA

11:19 am Discussion

11:24 am – 12:30 pm
Lunch *(Grand Canyon Ballroom)*
Visit Scientific Posters *(Grand Saguaro Foyer)*
& Technical Exhibits *(Grand Canyon Ballroom)*

11:24 am – 12:30 pm
New Member Luncheon
(tickets required)
(*Grand Sonoran E)*

11:24 am – 12:30 pm
Kathy Cramer, MD Memorial
Women in Orthopaedic Trauma Luncheon *(tickets required)*
(*Tuscany Restaurant)*

Chairs: *Leslie J. Gullahorn, MD and Laura S. Phieffer, MD*

11:35 am – 12:20 pm — **GUIDED POSTER TOURS** — ***Tickets Required***

Upper Extremity / Wrist / Hand *(#P2)* *(Grand Saguaro Foyer)*
Guide: *Michael D. McKee, MD*

Pelvis and Acetabulum *(#P3)* *(Grand Saguaro Foyer)*
Guide: *Paul Tornetta, III, MD*

12:30 - 2:00 pm
(Notes p. 230 - 231)

Concurrent Sessions
(Skills Labs, Mini Symposia and Symposium followed by Scientific Session run concurrently.)
- Skills Labs
- Mini Symposia
- Assessment of Fracture Repair Symposium
- Scientific Paper Session IV: Basic Science

See pages 91 - 132 for financial disclosure information.

12:30 – 2:00 pm | **SKILLS LABS** | ***Tickets Required***

Surgical Implant Generation Network (SIGN) *(#SL3)* *(Grand Sonoran C-D)*
Lab Leader: *Lewis G. Zirkle, Jr., MD*
Faculty: *Prof. Shabab-Uddin, MD; John W. Staeheli, MD; Kyle R. Stephens, DO; Paul S. Whiting, MD* and *Frederic B. Wilson, Jr., MD*

IM Fixation of Proximal Tibial Fractures *(#SL4)* *(Grand Sonoran J-K)*
Lab Leader: *Roy Sanders, MD*
Faculty: *Daniel R. Dziadosz, MD; Joshua Langford, MD; Frank Liporace, MD; Anthony S. Rhorer, MD* and *William M. Ricci, MD*

Knee or Ankle Spanning Ex-Fix *(#SL5)* *(Grand Sonoran H-I)*
Lab Leader: *Edward A. Perez, MD*
Faculty: *Hassan R. Mir, MD; Amer J. Mirza, MD; Matthew I. Rudloff, MD; John C. Weinlein, MD* and *Robert D. Zura, MD*

12:30 – 2:00 pm | **MINI SYMPOSIA** | ***No Tickets Required***

Contemporary Debates in Orthopaedic Trauma *(Pinnacle Peak 1)*
Moderator: *Michael Suk, MD, JD*
Faculty: *Samuel G. Agnew, MD; Bruce D. Browner, MD; Lisa K. Cannada, MD; Clifford B. Jones, MD; A. Alex Jahangir, MD; Douglas W. Lundy, MD; Theodore Toan Le, MD; Samir Mehta, MD; Manish K. Sethi, MD Philip R. Wolinsky, MD* and *Bruce H. Ziran, MD*

Financial Implications of Increasing ACS Trauma Level: Where Does the Orthopaedic Trauma Surgeon Fit into the Equation? *(Pinnacle Peak 2)*
Moderator: *Timothy J. Bray, MD*
Faculty: *Peter Althausen, MD; Austin Hill, MD, MPH* and *Mike Williams, MPA, HSA*

Introduction to ICD-10 for Orthopaedic Traumatologists *(Pinnacle Peak 3)*
Moderator: *M. Bradford Henley, MD*
Faculty: *J. Scott Broderick, MD* and *William R. Creevy, MD*

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12:30 – 1:40 pm SYMPOSIUM II: ASSESSMENT OF FRACTURE REPAIR

(Notes p. 232) **Moderators:** *Emil H. Schemitsch, MD*
Theodore Miclau, III, MD *(Grand Saguaro Ballroom)*

Faculty: *Michael J. Bosse, MD*
Michael D. McKee, MD
Saam Morshed, MD, PhD
Gerard P. Slobogean, MD, MPH
Paul Tornetta, III, MD

12:30 pm **What is the Problem and is there a Consensus?**
Michael D. McKee, MD

12:40 pm **Current Options for Determining Union**
Saam Morshed, MD, PhD

12:50 pm **What is the Role for Functional Outcomes?**
Gerard P. Slobogean, MD, MPH

1:00 pm **Are Fracture Healing Trials a Thing of Past: The Challenge of FDA**
Paul Tornetta, III, MD

1:10 pm **Focusing Our Efforts: Challenging Healing Problems, but What Will the Answers Be?**
Michael J. Bosse, MD

1:20 pm Discussion

SCIENTIFIC PAPER SESSION IV BASIC SCIENCE

(Grand Saguaro Ballroom)

1:40 – 2:04 pm

Moderators - Theodore Miclau, III, MD & Emil H. Schemitsch, MD

1:40 pm
(p. 233)
PAPER #55

Is There an International Consensus as to How to Assess Fracture Healing Based on Clinical and Radiological Findings?

Wojciech Glinkowski, MD, PhD[1]; *Jakub Janowicz, MD*[1];
Alexander N. Chelnokov, MD[2];
[1]Department of Orthopaedics and Traumatology of Locomotor System, Center of Excellence "TeleOrto" (Telediagnostics and Treatment of Disorders and Injuries of Locomotor System), Medical University of Warsaw, Warsaw, Poland;
[2]Ural Scientific Research Institute of Traumatology and Orthopaedics, Ekaterinburg, Russia

1:46 pm
(p. 235)
PAPER #56

Any Cortical Bridging Predicts Healing of Tibial Shaft Fractures

William Lack, MD; *James Starman, MD; Rachel Seymour, PhD;*
Michael J. Bosse, MD; Madhav Karunakar, MD; Stephen Sims, MD;
James Kellam, MD
Carolinas Medical Center, Charlotte, North Carolina, USA

See pages 91 - 132 for financial disclosure information.

1:52 pm (p. 237) PAPER #57	**Ultrasonographic Monitoring of Fracture Healing: Is This the End of Radiography in Fracture Follow-ups?** ***Sourabh Chachan, MBBS***; *Barsha Tudu, MBBS, MS (orth);* *Biswajit Sahu, MBBS, MS (orth);* *VSS Medical College, Burla, Sambalpur, Orissa, India*
1:58 pm	Discussion
2:04 pm – 2:30 pm	Refreshment Break *(Grand Canyon Ballroom)* Visit Scientific Posters *(Grand Saguaro Foyer)* & Technical Exhibits *(Grand Canyon Ballroom)*
2:30 - 4:00 pm (Notes p. 238)	**Concurrent Sessions** ***(Mini Symposia and Scientific Session run concurrently.)*** Mini Symposia Scientific Paper Session V: Knee/Tibia

2:30 – 4:00 pm

MINI SYMPOSIA

No Tickets Required

Technical Tips in 3 and 4-Part Proximal Humerus ORIF *(Pinnacle Peak 1)*
Moderator: *Utku Kandemir, MD*
Faculty: *Michael J. Gardner, MD; John T. Gorczyca, MD; Michael D. McKee, MD* and *Milan K. Sen, MD*

How to Establish and Run a Fragility Fracture Program *(Pinnacle Peak 2)*
Moderator: *James A. Goulet, MD*
Faculty: *Kyle J. Jeray, MD; Clifford B. Jones, MD; Joseph M. Lane, MD* and *Marc F. Swiontkowski, MD*

Healthcare Systems and Trauma: A 360 Degree World View for the Orthopaedic Trauma Surgeon *(Pinnacle Peak 3)*
Moderator: *Manish K. Sethi, MD*
Faculty: *James R. Ficke, MD; Samir Mehta, MD* and *Hassan R. Mir, MD*

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(Grand Saguaro Ballroom) **2:30 – 4:07 pm**	**SCIENTIFIC PAPER SESSION V** **KNEE / TIBIA** **Moderators - David W. Sanders, MD & David P. Barei, MD**

2:30 pm
(p. 239)
PAPER #58

Are Locked Plates Needed for Fixation of Split Depression Tibial Plateau Fractures (Schatzker Type II)?
Michelle Abghari, BS; *Alejandro I. Marcano, MD; Roy Davidovitch, MD; Sanjit Konda, MD; Kenneth A. Egol, MD;*
NYU Hospital for Joint Diseases, New York, New York, USA

2:36 pm
(p. 240)
PAPER #59

Δ Inflammatory Cytokine Response Following Tibial Plateau Fracture Does Not Correlate with Fracture Grading of "Low Versus High Energy"
Justin Haller, MD; *Erik Kubiak, MD; Thomas F. Higgins, MD;*
University of Utah, Salt Lake City, Utah, USA

2:42 pm Discussion

2:47 pm
(p. 242)
PAPER #60

Fix It or Discard It? A Retrospective Review of Functional Outcomes After Surgically Treated Patellar Fractures Comparing Open Reduction and Internal Fixation With Partial Patellectomy
Nicholas Bonnaig, MD; Chris Casstevens, MD; ***Michael T. Archdeacon, MD, MSE***;
University of Cincinnati Department of Orthopaedic Surgery, Cincinnati, Ohio, USA

2:53 pm
(p. 244)
PAPER #61

Time to Spanning External Fixation for High-Energy Tibial Plateau and Plafond Fractures has No Impact on Rates of Infection, Compartment Syndrome, or Secondary Procedures
Justin Haller, MD; *David Holt, MD; Erik Kubiak, MD; Thomas F. Higgins, MD;*
University of Utah, Salt Lake City, Utah, USA

2:59 pm Discussion

3:04 pm
(p. 246)
PAPER #62

Intramedullary Nailing With an Internal Compression Device for Transverse Tibial Shaft Fractures Decreases Time to Union When Compared to Traditional "Backslapping" and Dynamic Locking
Michael J. Beltran, MD; *Christopher R. James, MD; H. Claude Sagi, MD;*
Florida Orthopaedic Institute, Tampa, Florida, USA

3:10 pm
(p. 247)
PAPER #63

Can All Tibial Shaft Fractures Bear Weight Following Intramedullary Nailing? A Randomized Clinical Trial
Steven C. Gross, MD[1]; *David Taormina, MS*[2]; *Kenneth A. Egol, MD*[3];
Nirmal C. Tejwani, MD[3];
[1]*Carolinas Medical Center, Greensboro, North Carolina, USA;*
[2]*New York Medical College, Valhalla, New York, USA;*
[3]*NYU Hospital for Joint Diseases, New York, New York, USA*

Δ OTA Grant

See pages 91 - 132 for financial disclosure information.

3:16 pm (p. 248) PAPER #64	**Does a 6-Month Wait Before Reoperation Improve Tibial Nonunion Rates? A Comparative Examination of Patients Not Enrolled in SPRINT** ***Carol A. Lin, MD, MA****; for the SPRINT (Study to Prospectively Evaluate Reamed Intramedullary Nails in Patients with Tibial Fractures) Investigators;* *Hennepin County Medical Center, Minneapolis, Minnesota, USA*
3:22 pm	Discussion
3:27 pm (p. 249) PAPER #65	**What Is a "Critical Bone Defect" in Open Tibia Shaft Fractures Definitively Treated With an Intramedullary Nail?** ***Nikkole Haines, MD****; William Lack, MD; Rachel Seymour, PhD; Michael J. Bosse, MD;* *Carolinas Medical Center, Charlotte, North Carolina, USA*
3:33 pm (p. 251) PAPER #66	**Alignment After Intramedullary Nailing of Distal Tibia Fractures Without Fibula Fixation** *Anthony De Giacomo, MD; William R. Creevy, MD;* ***Paul Tornetta, III, MD****;* *Boston University Medical Center, Boston, Massachusetts, USA*
3:39 pm (p. 253) PAPER #67	**Outcomes of the Patients With Cultured Pathogens at the Time of Nonunion Surgery** ***David P. Taormina, MS****; James H. Lee, BE; Alejandro I. Marcano, MD; Raj Karia, MPH; Kenneth A. Egol, MD;* *Hospital for Joint Diseases, NYU Langone Medical Center, New York, New York, USA*
3:45 pm	Discussion
3:50 pm (p. 254) PAPER # 68	**Acute Compartment Syndrome: Where Pressure Fails, pH Succeeds** ***Kirsten G.B. Elliott, FRCS (Ortho), MD****; Alan J. Johnstone, FRCS;* *Aberdeen Royal Infirmary, Aberdeen, United Kingdom*
3:56 pm (p. 255) PAPER # 69	**Interobserver Reliability in the Measurement of Lower Leg Compartment Pressures** ***Thomas M. Large, MD****[1]; Julie Agel, MA[2]; Daniel J. Holtzman, MD[2]; Stephen K. Benirschke, MD[2]; James C. Krieg, MD[2];* *[1]Mission Hospital, Asheville, North Carolina, USA;* *[2]Harborview Medical Center, University of Washington, Seattle, Washington, USA*
4:02 pm	Discussion

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(Grand Saguaro Ballroom)

4:07 – 4:47 pm

SCIENTIFIC PAPER SESSION VI
PEDIATRICS and SPINE

Moderators - Gilbert R. Ortega, MD & Samir Mehta, MD

4:07 pm (p. 257) PAPER #70	**Displaced Medial Epicondyle Fractures in Children: Comparative Effectiveness of Surgical Treatment Versus Nonsurgical Treatment** ***Emily Mayer, BS***; *Charles T. Mehlman, DO, MPH;* *Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA*
4:13 pm (p. 258) PAPER #71	**A Prospective Cohort Study of the Adoption of Titanium Elastic Intramedullary Nails for the Treatment of Femur Fractures in Kumasi, Ghana** *Tai Holland, BS[1]; Scott P. Kaiser, MD[1];* ***Paa Kwesi Baidoo, MD[2]***; *Kate Liddle, BS[1]; Dominic Yeboah, MD[2]; Richard Coughlin, MD[1]; Dominic Awariyah, MD[2]; Peter Konadu, MD[2]; Raphael Kumah-Ametepey, MD[2];* *[1]Institute for Global Orthopaedics and Traumatology, Department of Orthopaedic Surgery, University of California, San Francisco, San Francisco, California, USA; [2]Department of Orthopaedic Surgery, Komfo Anokye Teaching Hospital, Kumasi, Ghana*
4:19 pm (p. 259) PAPER #72	**Refracture Rates Following Clavicle Shaft Fractures in Children: Angulation-Only Fractures Versus Completely Displaced Fractures** ***Michelle Masnovi, MS***; *Charles T. Mehlman, DO, MPH;* *Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA*
4:25 pm	Discussion
4:30 pm (p. 260) PAPER #73	**Predicting Redisplacements of Diaphyseal Forearm Fractures: How About the Three-Point Index?** *Serkan Iltar;* ***Kadir Bahadir Alemdaroglu, MD***; *Ferhat Say; Nevres H. Aydogan;* *Ankara Training and Research Hospital, Ankara, Turkey*
4:36 pm (p. 261) PAPER #74	**Factors Associated With Nonunion in 97 Consecutive Type 2 and Type 3 Odontoid Fractures in Elderly Patients** *Michael Merrick, MD[1]; Debra L. Sietsema, PhD[2,3]; Casey Smith, MD[1]; Tan Chen, BS[3]; Scott S. Russo, MD[2,3];* ***Clifford B. Jones, MD[2,3]***; *James R. Stubbart, MD[2,3];* *[1]Grand Rapids Medical Education Partners, Grand Rapids, Michigan, USA; [2]Orthopaedic Associates of Michigan, Grand Rapids, Michigan, USA; [3]Michigan State University, Grand Rapids, Michigan, USA*
4:42 pm	Discussion
4:47 pm	Adjourn

See pages 91 - 132 for financial disclosure information.

5:30 –
6:30 pm

OTA Military Reception
(*Desert Suite VIII)*
Hosted by the OTA Board of Directors and the OTA Military Committee (All Active Duty Military, Retired Military and all Landstuhl Distinguished Visiting Scholar participants invited.)

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ORTHOPAEDIC TRAUMA ASSOCIATION

2013 Annual Meeting

Saturday, October 12, 2013

6:00 am	**Speaker Ready Room** *(Grand Saguaro Foyer)*
6:15 am	**Continental Breakfast** *(Available at Breakout Sessions)*
	Attendee Registration *(Grand Saguaro Foyer)*
6:30 am	**Scientific Posters** (Technical Exhibits Open at 9:00 am) *(Grand Saguaro Foyer)*
	Continental Breakfast *(Grand Saguaro Foyer)*
6:30 - 7:45 am (Notes p. 262 - 263)	**Concurrent Breakout Sessions** Case Presentations Skills Lab Poster Tour

6:30 – 7:45 am — **CASE PRESENTATIONS** — ***No Tickets Required***

Surgical Treatment of Pediatric Femur Fractures, Current Concepts *(Pinnacle Peak 1)*
Moderator: *Enes Kanlic, MD, PhD*
Faculty: *Amr A. Abdelgawad, MD; J. Eric Gordon, MD* and *Marc F. Swiontkowski, MD*

Management of Pelvic and Acetabulum Fractures *(Pinnacle Peak 2)*
Moderator: *Paul Tornetta, III, MD*
Faculty: *Thomas F. Higgins, MD; Robert V. O'Toole, MD* and *Philip R. Wolinsky, MD*

The Isolated Humerus: Not All Belong in the Sarmiento *(Pinnacle Peak 3)*
Moderator: *Lisa K. Cannada, MD*
Faculty: *Clifford B. Jones, MD* and *William T. Obremskey, MD, MPH*

6:30 – 7:45 am — **SKILLS LAB** — ***Tickets Required***

ORIF Distal Radius Fractures *(#SL6)* *(Grand Sonoran A-B)*
Lab Leader: *Melvin P. Rosenwasser, MD*
Faculty: *Gregory DeSilva, MD; Michael D. McKee, MD; Matthew D. Putnam, MD; Saqib Rehman, MD* and *Thomas F. Varecka, MD*

See pages 91 - 132 for financial disclosure information.

7:00 – 7:45 am | **GUIDED POSTER TOUR** | *Tickets Required*

Hip and Femur *(#P4)* *(Grand Saguaro Foyer)*
Guide: *J. Tracy Watson, MD*

8:00 – 9:30 am SYMPOSIUM III: THE OPERATIVE VERSUS NON-OPERATIVE TREATMENT OF COMMON UPPER EXTREMITY INJURIES: WHAT DOES EVIDENCE-BASED MEDICINE TELL US?

(Notes p. 264) **Moderator:** *Michael D. McKee, MD* *(Grand Saguaro Ballroom)*
Faculty: *Peter A. Cole, MD*
Clifford B. Jones, MD
Stephane Pelet, MD, PhD
Melvin P. Rosenwasser, MD
Emil H. Schemitsch, MD

8:00 am **Introduction**
Michael D. McKee, MD

8:05 am **Fractures of the Clavicle**
Michael D. McKee, MD

8:15 am **Fractures of the Scapula**
Peter A. Cole, MD

8:25 am **Fractures of the Proximal Humerus**
Clifford B. Jones, MD

8:35 am **Acute Acromioclavicular Dislocations**
Stephane Pelet, MD, PhD

8:45 am **Fractures of the Humeral Shaft**
Emil H. Schemitsch, MD

8:55 am **Fractures of the Radial Head**
Michael D. McKee, MD

9:05 am **Fractures of the Distal Radius**
Melvin P. Rosenwasser, MD

9:15 am **Cases, Questions and Discussion**
All Faculty

9:30 am - 10:00 am
Refreshment Break *(Grand Canyon Ballroom)*
Visit Scientific Posters *(Grand Saguaro Foyer)*
& Technical Exhibits *(Grand Canyon Ballroom)*

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10:00 - 11:30 am (Notes p. 265)	**Concurrent Sessions** ***(Mini Symposia and Scientific Session run concurrently.)*** Mini Symposia Scientific Paper Session VII: Foot and Ankle

10:00 – 11:30 am **MINI SYMPOSIA** *No Tickets Required*

What Could Go Wrong Did: Getting Out of Trouble *(Pinnacle Peak 1)*
Moderator: *Lisa K. Cannada, MD*
Faculty: *Frank Liporace, MD; Brian H. Mullis, MD* and *David C. Templeman, MD*

Geriatric Pelvis and Acetabular Fractures: We Should Treat Them Like Hip Fractures *(Pinnacle Peak 2)*
Moderator: *Brett D. Crist, MD*
Faculty: *Michael T. Archdeacon, MD; Cory A. Collinge, MD; Steven A. Olson, MD;* and *Stephen A. Sems, MD*

Malunion / Nonunion Management: What I Wish Someone Had Told Me Before I Started Doing These Cases *(Pinnacle Peak 3)*
Moderator: *Samir Mehta, MD*
Faculty: *David P. Barei, MD; Gregory J. Della Rocca, MD, PhD* and *J. Spence Reid, MD*

(Grand Saguaro Ballroom)

SCIENTIFIC PAPER SESSION VII
FOOT and ANKLE

10:00 – 11:26 am **Moderators - Robert V. O'Toole, MD & Christopher M. Doro, MD**

10:00 am (p. 266) PAPER #75	**Δ Open Reduction and Internal Fixation Compared With Primary Subtalar Fusion for Treatment of Sanders Type IV Calcaneal Fractures: A Randomized Multicenter Clinical Trial** ***Richard E. Buckley, MD;*** *Canadian Orthopaedic Trauma Society*
10:06 am (p. 267) PAPER #76	**Combined Approaches Increase Nonunion in Tibial Pilon Fractures** ***Paul M. Balthrop, MD***[1]*; Daniel S. Chan, MD*[1]*; Brian White, MD, David Glassman, MD*[2]*; Roy Sanders, MD*[1]*;* [1]*Orthopaedic Trauma Service, Florida Orthopaedic Institute, Tampa, Florida, USA;* [2]*Naval Medical Center, Portsmouth, Virginia, USA*

Δ OTA Grant
See pages 91 - 132 for financial disclosure information.

10:12 am (p. 268) PAPER #77
Long-Term Follow-up of High-Energy Pilon Fractures: A Prospective Comparison of Locked Plates Versus Nonlocked Plates
Theodore T. Le, MD; ***Albert d'Heurle, MD****; Namdar Kazemi, MD; Michael T. Archdeacon, MD, MSE; John D. Wyrick, MD; University of Cincinnati Academic Health Center, Cincinnati, Ohio, USA*

10:18 am Discussion

10:23 am (p. 269) PAPER #78
Δ Early Weight Bearing and Mobilization Versus Non–Weight Bearing and Immobilization After Open Reduction and Internal Fixation of Unstable Ankle Fractures: A Randomized Controlled Trial
Niloofar Dehghan, MD[1]*; Richard Jenkinson, MD[2]; Michael McKee, MD[1]; Emil H. Schemitsch, MD[1]; Aaron Nauth, MD[1]; Jeremy Hall, FRCSC[1]; David Stephen, MD[2]; Hans J. Kreder, MD[2];*
[1]St. Michael's Hospital - University of Toronto, Toronto, Ontario, Canada
[2]Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada

10:29 am (p. 271) PAPER #79
Does the Müller AO Classification System for Ankle Fractures Correlate More Closely to the Mechanism of Injury Than the Lauge-Hansen System?
Edward K. Rodriguez, MD, PhD[1]; John Y. Kwon, MD[2]; Lindsay M. Herder, BA[1]; ***Paul T. Appleton, MD***[1]*;*
[1]Beth Israel Deaconess Medical Center, Boston, Massachusetts, USA
[2]Massachusetts General Hospital, Boston, Massachusetts, USA

10:35 am (p. 272) PAPER #80
The Quality and Utility of Routine Immediate Postoperative Radiographs Following Ankle Fracture Surgery
Elizabeth A. Martin, MD*; Sara Lyn Miniaci-Coxhead, MD; Joshua G. Hunter, MD; John T. Gorczyca, MD; Jonathan M. Gross, MD; Catherine A. Humphrey, MD; John P. Ketz, MD; University of Rochester Medical Center, Rochester, New York, USA*

10:41 am Discussion

10:46 am (p. 273) PAPER #81
A Prospective Randomized Multicentric Trial Comparing a Static Implant to a Dynamic Implant in the Surgical Treatment of Acute Ankle Syndesmosis Rupture
Mélissa Laflamme, MD[1]; Etienne L. Belzile, MD[1]; Luc Bédard, MD[1]; Michel van den Bekerom, MD[2]; Mark Glazebrook, MD[3]; ***Stéphane Pelet, MD, PhD***[1]*;*
[1]CHU de Québec, Quebec City, Quebec, Canada;
[2]Spaarne Ziekenhuis - Locatie Hoofddorp, Hoofddorp, The Netherlands;
[3]Dalhousie University, Halifax, Nova Scotia, Canada

10:52 am (p. 274) PAPER #82
The Fate of the Fixed Syndesmosis Over Time
Scott Koenig, MD; ***Elisabeth Gennis, MD****; Deirdre Rodericks, BS; Peters Otlans, BS; Paul Tornetta, III, MD; Boston University Medical Center, Boston, Massachusetts, USA*

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10:58 am
(p. 276)
PAPER #83

Does Syndesmotic Injury Have a Negative Effect on Functional Outcomes? A Multicenter Prospective Evaluation

Jody Litrenta, MD[1]; *Paul Tornetta, III, MD*[1]; *Laura S. Phieffer, MD*[2]; *Clifford Jones, MD*[3]; *Janos P. Ertl, MD*[4]; *Brian H. Mullis, MD*[4]; *Kenneth A. Egol, MD*[5]; *Michael J. Gardner, MD*[6]; *William M. Ricci, MD*[6]; *David C. Teague, MD*[7]; *William J. Ertl, MD*[7]; *Cory A. Collinge, MD*[8]; *Ross K. Leighton, MD*[9];
[1]*Boston University Medical Center, Boston, Massachusetts, USA;*
[2]*Ohio State University Medical Center, Columbus, Ohio, USA;*
[3]*Orthopaedic Associates of Michigan, Grand Rapid, Michigan, USA;*
[4]*Indiana University, Indianapolis, Indiana, USA;*
[5]*NYU Hospital for Joint Diseases, New York, New York, USA;*
[6]*Barnes-Jewish Hospital, St. Louis, Missouri, USA;*
[7]*University of Oklahoma, Oklahoma City, Oklahoma, USA;*
[8]*Orthopedic Specialty Associates, Fort Worth, Texas, USA;*
[9]*Dalhousie University, Halifax, Nova Scotia, Canada*

11:04 am — Discussion

11:09 am
(p. 278)
PAPER #84

Stress Ankle Radiographs and Predictability of Deep Deltoid Ligament Injury in a Supination–External Rotation Cohort

Patrick C. Schottel, MD; *Marschall B. Berkes, MD; Milton T.M. Little, MD; Matthew R. Garner, MD; Jacqueline Birnbaum, BS; David L. Helfet, MD; Dean G. Lorich, MD;*
Hospital for Special Surgery, New York, New York, USA

11:15 am
(p. 279)
PAPER #85

Anatomical Fixation of Supination–External Rotation Type IV Equivalent Ankle Fractures

Milton T.M. Little, MD; *Marschall B. Berkes, MD; Patrick C. Schottel, MD; Matthew Garner, MD; Lionel E. Lazaro, MD; Jacqueline F. Birnbaum, BA; David L. Helfet, MD; Dean G. Lorich, MD;*
Hospital for Special Surgery/New York Presbyterian-Cornell, New York, New York, USA

11:21 am — Discussion

11:26 am – 12:30 pm — Lunch *(Grand Canyon Ballroom)*
LAST OPPORTUNITY TO VISIT Scientific Posters & Technical Exhibits

11:40 am – 12:25 pm GUIDED POSTER TOURS

Tickets Required

Geriatric *(#P5)* *(Grand Saguaro Foyer)*
Guide: *William T. Obremskey, MD, MPH*

General Interest *(#P6)* *(Grand Saguaro Foyer)*
Guide: *Lisa K. Cannada, MD*

See pages 91 - 132 for financial disclosure information.

12:30 - 2:00 pm **Concurrent Sessions** ***(Mini Symposia and Scientific Session run concurrently.)***
(Notes p. 281)
Mini Symposia
Scientific Session VIII: Topics of General Interest

12:30 – 2:00 pm

MINI SYMPOSIA

Management of Pediatric Trauma Urgencies / Emergencies *(Pinnacle Peak 1)*
Moderator: *David A. Podeszwa, MD*
Faculty: *Christine A. Ho, MD; Anthony I. Riccio, MD* and *Robert L. Wimberly, MD*

Rib Fracture Fixation in 2013: Lunatic Fringe or State of the Art? *(Pinnacle Peak 2)*
Moderator: *Michael D. McKee, MD*
Faculty: *Peter Althausen MD; Niloofar Dehghan, MD; Morad Hameed, MD; Aaron Nauth, MD; Emil H. Schemitsch, MD* and *Gerard P. Slobogean, MD*

Orthopaedic Surgeons Taking Ownership of Extremity Trauma: Soft Tissue Coverage *(Pinnacle Peak 3)*
Moderator: *Christopher M. McAndrew, MD*
Faculty: *Martin I. Boyer, MD; Duretti Fufa, MD; Daniel A. Osei, MD;* and *David A. Volgas, MD*

(Grand Saguaro Ballroom)

12:30 – 1:56 pm

SCIENTIFIC PAPER SESSION VIII
TOPICS OF GENERAL INTEREST

Moderators - Thomas F. Higgins, MD & Matt L. Graves, MD

12:30 pm
(p. 282)
PAPER #86

Utilizing the ASA Score as a Predictor of 90-Day Perioperative Readmission in Patients With Isolated Orthopaedic Trauma Injuries
Vasanth Sathiyakumar, BA; Aaron Yengo-Kahn, BS; Harrison F. Kay, BS; R. Adams Cowley; Young M. Lee, BS; Jesse M. Ehrenfeld, MD, MPH; William T. Obremskey, MD, MPH; ***Manish K. Sethi, MD****;*
Vanderbilt University, Nashville, Tennessee, USA

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12:36 pm (p. 284) PAPER #87	**Do Surgeons Know the Cost of Orthopaedic Trauma Implants? A Multicenter Study of 503 Surgeons** ***Kanu Okike, MD, MPH***[1]; *Robert V. O'Toole, MD*[1]; *Andrew N. Pollak, MD*[1]; *Julius A. Bishop, MD*[2]; *Christopher M. McAndrew, MD*[3]; *Samir Mehta, MD*[4]; *William Cross, MD*[5], *Grant Garrigues, MD*[6]; *Mitchel B. Harris, MD*[7]; *Christopher T. Lebrun, MD*[1]; [1]*University of Maryland, Baltimore, Maryland, USA;* [2]*Stanford University, Palo Alto, California, USA;* [3]*Washington University, St Louis, Missouri, USA;* [4]*University of Pennsylvania, Philadelphia, Pennsylvania, USA;* [5]*Mayo Clinic, Rochester, Minnesota, USA;* [6]*Duke University, Durham, North Carolina, USA;* [7]*Brigham and Women's Hospital, Boston, Massachusetts, USA*
12:42 pm (p. 286) PAPER #88	**Does Fracture Care Make Money for the Hospital? An Analysis of Hospital Revenue and Cost for Treatment of Common Fractures** ***Conor Kleweno, MD***; *Robert O'Toole, MD; Jeromie Ballreich, MHS; Andrew Pollak, MD;* *R Adams Cowley Shock Trauma Center, Department of Orthopaedic Surgery, University of Maryland School of Medicine, Baltimore Maryland, USA*
12:48 pm	Discussion
12:53 pm (p. 288) PAPER #89	**Sleep Disturbance Following Fracture Is Related to Emotional Well-Being Rather Than Functional Result** ***Brandon S. Shulman, BA***[1]; *Frank Liporace, MD*[1]; *Roy I. Davidovitch, MD*[1]; *Raj J. Karia, MPH*[1]; *Kenneth A. Egol, MD*[1,2]; [1]*NYU Hospital for Joint Diseases, New York, New York, USA;* [2]*Jamaica Medical Center, Jamaica, New York, USA*
12:59 pm (p. 289) PAPER #90	**Anxiety and Depression in the Etiology of Chronic Pain: Results from a Two-Year Cohort Study of Trauma Patients** ***Renan C. Castillo, PhD***[1]; *Stephen T. Wegener, PhD*[2]; *Sara E. Heins, BA*[1]; *Jennifer A. Haythornthwaite*[2]; *Ellen J. MacKenzie, PhD*[1]; *Michael J. Bosse, MD*[3]; *the LEAP (Lower Extremity Assessment Project) Study Group;* [1]*Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA;* [2]*Johns Hopkins Medicine, Baltimore, Maryland, USA;* [3]*Carolinas Medical Center, Charlotte, North Carolina, USA*
1:05 pm (p. 290) PAPER #91	**Δ Impact of Early Postoperative Pain on Outcomes One Year Following Traumatic Orthopaedic Injury** ***Kristin R. Archer, PhD***[1]; *Sara E. Heins*[2]; *Christine M. Abraham, MA*[1]; *William T. Obremskey, MD, MPH*[1]; *Stephen T. Wegener, PhD*[3]; *Renan C. Castillo, PhD*[2]; [1]*Vanderbilt University Medical Center, Nashville, Tennessee, USA;* [2]*Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA;* [3]*Johns Hopkins Medicine, Baltimore, Maryland, USA*
1:11 pm	Discussion

Δ OTA Grant

See pages 91 - 132 for financial disclosure information.

1:16 pm (p. 291) PAPER #92	**Nature's Wrath: The Effect of Daily Weather Patterns on Postoperative Pain Following Orthopaedic Trauma** ***Brandon S. Shulman, BA[1]***; *Alejandro I. Marcano, MD[1]; Roy I. Davidovitch, MD[1]; Raj J. Karia, MPH[1]; Kenneth A. Egol, MD[1,2]; [1]NYU Hospital for Joint Diseases, New York, New York, USA; [2]Jamaica Medical Center, Jamaica, New York, USA*
1:22 pm (p. 292) PAPER #93	**Health Literacy in an Orthopaedic Trauma Population: Improving Patient Comprehension Reduces Readmission Rates** *Rishin J. Kadakia, BSc; James M. Tsahakis, BA; Neil M. Issar, BSc; Harrison F. Kay, BSc; Kristin R. Archer, PhD, DPT;* ***Hassan R. Mir, MD****; Vanderbilt University Medical Center, Nashville, Tennessee, USA*
1:28 pm (p. 293) PAPER #94	**Stress Hyperglycemia Is Associated With Surgical Site Infection: A Prospective Observational Study of Nondiabetic, Noncritically Ill Orthopaedic Trauma Patients** ***Justin E. Richards, MD***; *Julie Hutchinson, ACNP; Kaushik Mukherjee, MD, MSCI; A. Alex Jahangir, MD; Hassan R. Mir, MD; Jason M. Evans, MD; Aaron M. Perdue, MD; William T. Obremskey, MD, MPH; Manish K. Sethi, MD; Addison K. May, MD; Vanderbilt University Medical Center, Nashville, Tennessee, USA*
1:34 pm	Discussion
1:39 pm (p. 294) PAPER #95	**Effectiveness of Vitamin D Therapy in Orthopaedic Trauma Patients** ***Brett D. Crist, MD***; *Daniel S. Robertson, MD; Tyler Jenkins, MD; Yvonne M. Murtha, MD; Gregory J. Della Rocca, MD, PhD; David A. Volgas, MD, James P. Stannard, MD; University of Missouri; Columbia, Missouri, USA*
1:45 pm (p. 295) PAPER #96	**Are Routine 2-Week Postoperative Radiographs Useful?** ***Brian Mosier[1]***; *Gregory T. Altman, MD[1], Lisa Taitsman, MD[2]; [1]Department of Orthopaedic Surgery, Allegheny General Hospital, Pittsburgh, Pennsylvania, USA; [2]Department of Orthopaedic Surgery, Harborview Medical Center, Seattle, Washington, USA*
1:51 pm	Discussion
1:56 – 2:26 pm	Refreshment Break *(Grand Saguaro Foyer)*

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(Grand Saguaro Ballroom)

SCIENTIFIC PAPER SESSION IX
UPPER EXTREMITY

2:26 – 3:35 pm

Moderators - Stephen A. Kottmeier, MD & Clifford B. Jones, MD

2:26 pm
(p. 296)
PAPER #97

Nonoperative Treatment of Closed Extra-Articular Distal-Third Diaphyseal Fractures of the Humerus: A Comparison of Functional Bracing and Long Arm Casting

*H.J. Christiaan Swellengrebel, MS[1]; **David Saper, MD**[2]; Paul Yi, BS[2]; Ryan Shin, MD[2]; David Ring, MD, PhD[1]; Andrew Jawa, MD[2];*
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2:32 pm
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PAPER #98

Functional Outcome Scores of Humeral Shaft Fractures in Patients Treated Nonoperatively Compared to Those Treated Surgically

***Edward Shields, MD**; Michael Maceroli, MD; Leigh Sundem; Sean Childs; Adrian Hadiono; Catherine Humphrey, MD; Jonathan Gross, MD; John Ketz, MD; John Gorczyca, MD;*
University of Rochester, Strong Memorial Hospital, Rochester, New York, USA

2:38 pm
(p. 298)
PAPER #99

A Prospective Randomized Study of Operative Treatment for Noncomminuted, Humeral Shaft Fractures: Open Plating Versus Minimally Invasive Plate Osteosynthesis (MIPO)

*Kichul Park, MD[1]; Chang-Wug Oh, MD[2]; Young-Soo Byun, MD[3]; Jung Jae Kim, MD[4]; **Ji Wan Kim, MD**[5];*
[1]Hanyang University Guri Hospital, Hanyang University, Guri, Repulbic of Korea;
[2]Kyungpook National Hospital, Kyungpook National University, Dae-gu, Republic of Korea;
[3]Daegu Fatima Hospital, Daegu, Republic of Korea;
[4]Asan Medical Center, University of Ulsan, Seoul, Republic of Korea;
[5]Haeundae Paik Hospital, Inje University, Busan, Republic of Korea

2:44 pm

Discussion

2:49 pm
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PAPER #100

Upright Compared to Supine Radiographs of Clavicle Fractures: Does Patient Positioning Affect Displacement?

***Jonathon D. Backus**[1]; David J. Merriman, MD[2]; Michael J. Gardner, MD[1]; Christopher M. McAndrew, MD[1]; William M. Ricci, MD[1];*
[1]Washington University in St. Louis, Department of Orthopedic Surgery, St. Louis, Missouri, USA;
[2]Mercy Clinic, Springfield, Missouri, USA

2:55 pm
(p. 300)
PAPER #101

Can Complications of Locked Plating About the Proximal Humerus Fractures Be Minimized? The Effect of the Learning Curve

***Kenneth A. Egol, MD**[1,2]; Brandon S. Shulman, BA[1]; Crispin C. Ong, MD[1]; David P. Taormina, MS[1]; Raj J. Karia, MPH[1]; Joseph D. Zuckerman, MD[1];*
[1]NYU Hospital for Joint Diseases, New York, New York, USA;
[2]Jamaica Medical Center, Jamaica, New York, USA

See pages 91 - 132 for financial disclosure information.

3:01 pm
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PAPER #102

Minimally Displaced Radial Head/Neck Fractures (Mason Type I, OTA Types 21A2.2 and 21B2.1): Are We "Overtreating" Our Patients?

Brandon S. Shulman, BA; *James H. Lee, BE; Frank Liporace, MD; Kenneth A. Egol, MD;*
Department of Orthopaedics, Hospital for Joint Diseases, NYU Medical Center, New York, New York, USAD

3:07 pm — Discussion

3:12 pm
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PAPER #103

PROMIS Physical Function Computer-Adaptive Test Compared to Other Upper Extremity Outcome Measures in the Evaluation of Proximal Humerus Fractures in Patients Over 60 Years of Age

Jordan H. Morgan, BS[1]; *Kanu Okike, MD*[1]; *Michael Kallen, PhD, MPH*[2]; *Mark Vrahas, MD*[1];
[1]*Brigham and Women's Hospital and Massachusetts General Hospital, Boston, Massachusetts, USA;*
[2]*Northwestern University Feinberg School of Medicine, Chicago, Illinois, USA*

3:18 pm
(p. 304)
PAPER #104

Pain Exposure Physical Therapy Versus Conventional Therapy in Patients With Complex Regional Pain Syndrome Type 1: A Randomized Controlled Trial

Karlijn J. Barnhoorn, MD; Henk van de Meent, MD, PhD; Robert T.M. van Dongen, MD, PhD; Frank P. Klomp; Hans Groenewoud, MSc; Ria M.W.G. Nijhuis-van der Sanden, PhD; ***Jan Paul M. Frölke, MD, PhD***[1];
Radboud University Nijmegen Medical Centre, Nijmegen, The Netherlands

3:24 pm
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PAPER #105

When Do Distal Radius Fractures Most Likely Displace and When Do They Stop Moving: Long-Term Follow-up of Closed Reduction and Casting

Andrew Jawa, MD; ***Joey Lamartina, MD***; *Paul Tornetta, III, MD;*
Boston University Medical Center, Boston, Massachusetts, USA

3:30 pm — Discussion

3:35 pm — Closing Remarks

3:40 pm — Adjourn

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Poster #1
(p. 307)
Quantification of Lateral Calcaneus Exposure Through the Extensile Lateral and Sinus Tarsi Approaches
Katherine M. Bedigrew, MD; *James A. Blair, MD; Daniel R. Possley, DO; Kevin L. Kirk, DO; Joseph R. Hsu, MD;*
San Antonio Military Medical Center, San Antonio, Texas, USA

Poster #2
(p. 308)
Outcomes of Fasciocutaneous Flaps for Lower Extremity Trauma
David Volgas, MD; *Gregory Della Rocca, MD; Brett Crist, MD; James Stannard, MD;*
University of Missouri, Columbia, Missouri, USA

Poster #3
(p. 309)
Ankle Injury Pattern in a Maisonneuve Fracture Cohort: An MRI Study
Patrick C. Schottel, MD; *Keith Hentel, MD; Jacqueline Birnbaum, BS; David L. Helfet, MD; Dean G. Lorich, MD;*
Hospital for Special Surgery, New York, New York, USA

Poster #4
(p. 310)
•The Effects of Elevation, Simulated Injury and Immobilization on Muscle Perfusion: A Near-Infrared Spectroscopy Study in Humans
Ariel Palanca, MD; Arthur Yang, BS; ***Julius A. Bishop, MD***;
Stanford Hospitals & Clinics, Stanford, California, USA

Poster #5
(p. 312)
Predicting Successful Limb Salvage in Open Calcaneal Fractures Sustained During Recent Combat Operations: A Predictive Model using Patient- and Injury-Specific Variables
Adam J. Bevevino, MD; *Jonathan F. Dickens, MD; Theodora Dworak, MD; Wade T. Gordon, MD; Benjamin K. Potter, MD; Jonathan A. Forsberg, MD;*
Walter Reed National Military Medical Center, Bethesda, Maryland, USA

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Poster #6 (p. 313)

Heel Pad Avulsion Injury: Classification and Role of Primary Topical Oxygen Therapy

Shobha S. Arora; Amite Pankaj, MBBS, MS, MRCS;
Kutbuddin Akbary, MBBS*; Tarun Vijay, MBBS, MS;*
Prakash Agarwal, MBBS, MS; Jaswinder Singh, MBBS, MS;
Nishant Soni, MBBS, MS; Binit Monga, MBBS, MS;
Department of Orthopedics, University College of Medical Sciences and GTB Hospital, Delhi, India

Poster #7 (p. 314)

Course of Treatment and Rate of Successful Salvage Following the Diagnosis of Deep Infection in Patients Treated for Pilon Fractures (AO/OTA 43)

Cesar S. Molina, MD*; Andrew R. Fras, MD; Jason M. Evans, MD;*
Vanderbilt University Medical Center – Orthopedic Trauma Institute, Nashville, Tennessee, USA

Poster #8 (p. 315)

Ankle Radiographs in the Early Postoperative Period: Do they Matter?

Matthew R. McDonald, BS; Jesse M. Ehrenfeld, MD, MPH;
A. Alex Jahangir, MD, MMHC; Vasanth Sathiyakumar, BA;
Jordan C. Apfeld, BA; William T. Obremskey, MD, MPH;
Manish K. Sethi, MD*;*
Vanderbilt University, Nashville, Tennessee, USA

Poster #9 (p. 317)

Calcaneal Avulsion Fractures: A Case Series and Prognostic Factors

Ida Leah Gitajn, MD*; Mostafa Abousayed, MD; Rull James Toussaint, MD;*
Mark Vrahas, MD; John Y. Kwon, MD;
Massachusetts General Hospital, Department of Orthopaedic Surgery, Boston, Massachusetts, USA

Poster #10 (p. 319)

Ankle Fractures and Employment: A Life-Changing Event for Patients

Perrin T. Considine, BS*; Benjamin Hooe, BS; Vasanth Sathiyakumar, BA;*
Gerald Onuoha II, BS; Julian K. Hinson, BA; Jordan C. Apfeld, BA;
William T. Obremskey, MD, MPH; Manish K. Sethi, MD;
Vanderbilt University, Nashville, Tennessee, USA

Poster #11 (p. 321)

The Treatment of Comminuted Talar Neck Fractures: The Effect of Lateral Plate Augmentation on Outcomes

Matthew J. Wolenski, MD[1]; ***John P. Ketz, MD[2]****; Roy W. Sanders, MD[1];*
[1]Florida Orthopaedic Institute, Tampa, Florida, USA;
[2]University of Rochester, Rochester, New York, USA

Poster #12 (p. 322)

Effect of Chronic Heavy Smoking on Ankle Fracture Healing

Waseem Jerjes, MD, PhD*; Hiang Boon Tan, MB, CHB;*
Peter V. Giannoudis, MD;
Academic Unit of Trauma and Orthopaedic Surgery, School of Medicine, University of Leeds, Leeds, United Kingdom

See pages 91 - 132 for financial disclosure information.

Poster #13 (p. 324)

Temporary External Fixation for Provisional Reduction of Displaced OTA 82-C Calcaneus Fractures

Babar Shafiq, MD[1]; *Brian Buck, MD*[2]; *Timothy G. Hiesterman, DO*[3]; *Josh Olson*[4]; *Peter A. Cole, MD*[4];
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[2]*Department of Orthopaedic Surgery, University of Missouri Health Care, Columbia, Missouri, USA;*
[3]*Department of Orthopaedic Surgery, St. Cloud Orthopedics, Sartell, Minnesota, USA;*
[4]*Department of Orthopaedic Surgery, University of Minnesota/Regions Hospital, St. Paul, Minnesota, USA*

Poster #14 (p. 325)

Thyroxin Level Control in Hypothyroid Patients and Ankle Fracture Healing

Waseem Jerjes, MD, PhD; *Hiang Boon Tan, MB, CHB; Peter V. Giannoudis, MD;*
Academic Unit of Trauma and Orthopaedic Surgery, School of Medicine, University of Leeds, Leeds, United Kingdom

Poster #15 (p. 326)

Resistance to Forced Dorsiflexion of 6 Plaster Short Leg Splint Designs

John R. West Sr, MD; ***Andrew H. Gage, BS***; *Nicole Sprentall, BS; Christopher E. Mutty, MD;*
Department of Orthopaedic Surgery, State University of New York at Buffalo, Buffalo, New York, USA

Poster #16 (p. 328)

Outcomes of Transsyndesmotic Ankle Fracture Dislocations— The "Log Splitter"

Jesse E. Bible, MD; *Priya G. Sivasubramaniam, BA; A. Alex Jahangir, MD; Jason M. Evans, MD; Hassan R. Mir, MD;*
Vanderbilt Orthopaedic Institute, Nashville, Tennessee, USA

GERIATRIC

Poster #17 (p. 329)

Hemiarthroplasty Versus Osteosynthesis for Undisplaced and Stable Femoral Neck Fractures

Kaan S. Irgit, MD; Raveesh D. Richard, MD; Andrew L. Cornelius, MD; Thomas R. Bowen, MD; Cassondra Andreychik; ***Daniel S. Horwitz, MD***;
Geisinger Health System, Danville, Pennsylvania, USA

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Poster #18
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Comparison of Lateral Locked Plating With Additional Distal Fixation and Antiglide Plating for Fixation of Distal Fibular Fractures in Osteoporotic Bone

Robert J. Wetzel, MD[1]; *Neel P. Jain, MD*[2]; *Paul J. Switaj, MD*[1];
Brian M. Weatherford, MD[1]; *Mahesh Polavarapu, BS*[1]; *Yupeng Ren, PhD*[3];
Xin Guo, MS[3]; *Li-Qun Zhang, PhD*[1,3]; *Bradley R. Merk, MD*[1];
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Poster #19
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A Simple Way to Improve Hospital Medical Care for Hip Fracture Patients: Testing Protein Levels

Yael Sagy; Ahuva Weiss-Meilik; Shani Gershtein; Moshe Salai;
Ely L. Steinberg, MD;
Department of Orthopaedic Surgery, Tel-Aviv Sourasky Medical Center, Sackler Faculty of Medicine, Tel-Aviv University, Tel-Aviv, Israel

Poster #20
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Immediate Weight Bearing as Tolerated After Locked Plating of Fragility Fractures of the Femur

Seth Criner, DO; *Jacqueline Krumrey, MD;*
Good Samaritan Regional Medical Center, Corvallis, Oregon, USA

Poster #21
(p. 334)

Atypical Femur Fractures in Patients on Chronic Bisphosphonates: Does Geometry Matter?

Jennifer Hagen, MD; *James Krieg, MD; Susan Ott, MD; Timothy Alton, MD;*
University of Washington, Seattle, Washington, USA

Poster #22
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Locked Plating Versus Nonoperative Management of Displaced Proximal Humerus Fractures in the Elderly

Kanu Okike, MD, MPH[1]; *Olivia C. Lee, MD*[2]; *Heeren Makanji, BA*[3];
Jordan H. Morgan, BS[4], *Mitchel B. Harris MD*[5], *Mark S. Vrahas MD*[4];
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[4]*Department of Orthopaedic Surgery, Massachusetts General Hospital, Boston, Massachusetts, USA;*
[5]*Department of Orthopaedic Surgery, Brigham and Women's Hospital, Boston, Massachusetts, USA*

Poster #23
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Geriatric Fractures About the Hip: Divergent Patterns in the Proximal Femur and Acetabulum

Matthew P. Sullivan, MD; *Keith D. Baldwin, MD, MPH;*
Derek J. Donegan, MD; Samir Mehta, MD, PhD; Jaimo Ahn, MD, PhD;
Hospital of the University of Pennsylvania, Department of Orthopaedic Surgery, Philadelphia, Pennsylvania, USA

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Poster #24 (p. 337)

The Inclusion of Patients With Cognitive Impairment in Hip Fracture Trials: A Missed Opportunity--Systematic Review

Simran Mundi, BHSc (cand); ***Harman Chaudhry, MD****;*
Mohit Bhandari, MD, PhD, FRCSC;
Division of Orthopaedic Surgery, McMaster University, Hamilton, Ontario, Canada

Poster #25 (p. 338)

Does Age Affect Healing Time and Functional Outcomes After Fracture Nonunion Surgery?

David P. Taormina, MS; Brandon S. Shulman, BA; Raj Karia, MPH; Allison B. Spitzer, MD; Sanjit R. Konda, MD; ***Kenneth A. Egol, MD****;*
Hospital for Joint Diseases, NYU Langone Medical Center, New York, New York, USA

Poster #26 (p. 339)

Bone Stock Distribution Along Transsacral Corridors in the Elderly and Its Relevance to Sacral Insufficiency Fractures

Daniel Wagner, MD[1,2]*; Lukas Kamer, MD*[2]*; Takeshi Sawaguchi, MD*[3]*; Hansrudi Noser, PhD*[1]*; Pol M. Rommens, MD*[2]*;*
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[2]*Department of Trauma Surgery, University Medical Center Mainz, Mainz, Germany;*
[3]*Department of Orthopedics & Joint Reconstructive Surgery, Toyama Municipal Hospital, Toyama, Japan*

Poster #27 (p. 341)

Preoperative Cognitive Impairment, Pain, and Psychological Stress in Hospitalized Elderly Hip Fracture Patients

Alan H. Daniels, MD*; Lori A Daiello, PharmD, ScM; Craig R Lareau, MD; Daniel L Aaron, MD; Kathryn A. Robidoux, BA; Wylie Luo, BA; Roman A. Hayda, MD; Christopher T. Born, MD*
Warren Alpert Medical School of Brown University and Rhode Island Hospital, Providence, Rhode Island, USA

Poster #28 (p. 343)

The Disutility of Preoperative Diagnostic Testing for Geriatric Hip Fractures

Joseph Bernstein, MD, MS; Francis O. Roberts; Samir Mehta, MD; ***Jaimo Ahn, MD, PhD****;*
University of Pennsylvania, Philadelphia, Pennsylvania, USA

Poster #29 (p. 344)

Transfusion Practices in Geriatric Hip Fractures: A Survey of Orthopaedic Traumatologists and Residents

Collin J. May, MD[1]*; Lauren K. Ehrlichman, MD*[1]*; Edward K. Rodriguez, MD, PhD*[2]*;*
[1]*Massachusetts General Hospital, Boston, Massachusetts, USA*
[2]*Beth Israel Deaconess Medical Center, Boston, Massachusetts, USA*

Poster #30 (p. 345)

The Utility of Injury Severity Indices in the High-Energy Geriatric Trauma Population with High-Mortality Orthopaedic Injuries

Sanjit R. Konda MD*; William D. Lack, MD; Matthew Wilson, MD; Rachel Seymour, PhD; Madhav A. Karunakar, MD;*
Carolinas Medical Center, Charlotte, North Carolina, USA

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Poster #31
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Risk Factors for Inpatient Mortality in High-Energy Geriatric Trauma Patients With Shoulder Girdle Fractures

Sanjit R. Konda MD; *Matthew Wilson, MD; Rachel Seymour, PhD; Madhav A. Karunakar, MD;*
Carolinas Medical Center, Charlotte, North Carolina, USA

Poster #32
(p. 348)

Geriatric Hip Fractures and Intra-Hospital Testing: Predicting Costs Utilizing the ASA Score

Vasanth Sathiyakumar, BA; Jordan C. Apfeld, BA; Young M. Lee, BS; Daniel Sutton, BS; Jesse M. Ehrenfeld, MD, MPH; Benjamin Hooe, BS; William T. Obremskey, MD, MPH; ***Manish K. Sethi, MD***;
Vanderbilt University, Nashville, Tennessee, USA

Poster #33
(p. 350)

Periprosthetic Femur Fractures: 1-Year Mortality Rates for Open Reduction and Internal Fixation and Revision Arthroplasty

Natalie Casemyr, MD[1]; *Collin May, MD*[1]; *Mark Vrahas, MD*[1]; *Michael J. Weaver, MD*[2]; *Edward K. Rodriguez, MD*[3]; *Mitchell Harris, MD*[2];
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[2]*Brigham and Women's Hospital, Boston, Massachusetts, USA;*
[3]*Beth Israel Deaconess Medical Center, Boston, Massachusetts, USA*

Poster #34
(p. 352)

Retrospective Comparison of Short Versus Long Cephalomedullary Nails for the Treatment of Unstable Intertrochanteric Fractures

Michael Charters, MD, MS; *Nicholas Frisch, MD, MBA; Wael Ghacham, MD; Christopher Dobson, BS; Jad Khalil, MD; Joseph Hoegler, MD; Stuart T. Guthrie, MD; William Hakeos, MD; Clifford Les, DVM, PhD;*
Henry Ford Hospital, Detroit, Michigan, USA

Poster #35
(p. 353)

Cost-Effective Analysis of an Implantable Hip Strengthening Device Compared to Bisphosphonates for Reducing Contralateral Hip Fractures in "At-Risk" Patients

Sahaja Patel, MS[1]; *Robert L. Burden, MEng*[1,2]; ***Michael J. Voor, PhD***[1,2];
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Poster #36
(p. 355)

Radiographic Predictors of Screw Cut-Out for Intertrochanteric Fractures Treated With Linear Compression Cephalomedullary Nails

Michael Charters, MD, MS; *Wael Ghacham, MD; Nicholas Frisch, MD, MBA; Christopher Dobson, BS; Jad Khalil, MD; Joseph Hoegler, MD; Stuart T. Guthrie, MD; William Hakeos, MD; Clifford Les, DVM, PhD;*
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Poster #37
(p. 356)

Acetabulum Fractures in Elderly Patients: Which Injury and Treatment Characteristics Are Associated With the Best Outcomes?

Nicholas R. Scarcella, BS; Erik Schnaser, MD; ***Heather A. Vallier, MD***;
MetroHealth Medical Center, Cleveland, Ohio, USA

See pages 91 - 132 for financial disclosure information.

HIP and FEMUR

Poster #38 (p. 358)

•Dynamic Locked Plating of Comminuted Distal Femur Fractures: A Matched Cohort Study

Michael J. Gardner, MD*; Patricia Babb, MSW; Christopher M. McAndrew, MD; William M. Ricci, MD; Orthopaedic Trauma Service, Washington University School of Medicine, St Louis, Missouri, USA*

Poster #39 (p. 360)

Management of Closed Femur Fractures with the SIGN Intramedullary Nail in Two Developing African Countries

Kyle R. Stephens, DO[1]*; Daniel Galat, MD*[2]*; Duane Anderson, MD*[3]*; Kiprono G. Koech, MD*[2]*; Paul Whiting, MD*[4]*; Michael Mwachiro, MD*[2]*; Douglas W. Lundy, MD*[5]*;*
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Poster #40 (p. 361)

Is Prophylactic Intramedullary Nailing for Bisphosphonate-Associated Incomplete Femoral Fractures a Cost-Effective Treatment Strategy?

James H. Lee, BE; Michelle S. Abghari, BS; Zehava S. Rosenberg, MD; Nirmal C. Tejwani, MD; ***Kenneth A. Egol, MD****; Hospital for Joint Diseases, NYU Langone Medical Center, New York, New York, USA*

Poster #41 (p. 362)

Femoral Neck Fracture Reduction: Is Our Interpretation of Intraoperative Fluoroscopy Accurate?

Matt L. Graves, MD[1]*; Matt Futvoye, MD*[1]*; Robert O'Toole, MD*[2]*; Jason Nascone, MD*[2]*; David P. Barei, MD, FRCSC*[3]*; Lisa A. Taitsman, MD*[3]*; George V. Russell Jr., MD*[1]*;*
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[2]*University of Maryland Medical Center, Baltimore, Maryland, USA;*
[3]*Harborview Medical Center, Seattle, Washington, USA*

Poster #42 (p. 363)

Retrograde Versus Antegrade Femoral Nailing of Gunshot Femur Fractures

Paul J. Dougherty, MD*; Petra Gherebeh, MD; Mark Zekaj; Sajiv Sethi; Bryant Oliphant, MD; Rahul Vaidya, MD; Detroit Receiving Hospital, Detroit, Michigan, USA*

Poster #43 (p. 364)

Implant and Radiography Decisions in the Treatment of High-Angle "Vertical" Femoral Neck Fractures in Young Adult Patients: An Expert Opinion Survey

Kevin Luttrell, MD[1]*; Cory Collinge, MD*[1;2]
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Poster #44
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In Situ Proximal Femur Positioning and Radiographic Landmark Measurements: How Accurate Are We?

Jacob L. Cartner, MS[1]; *Naoya Takada, MD*[2]; *John Williams, PhD*[3];
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Poster #45
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Incidence of Reoperation Following Internal Fixation of Femoral Neck Fractures in Adults Age 60 Years or Less: A Meta-Analysis

Gerard P. Slobogean MD, MPH, FRCSC[1]; *Sheila A. Sprague MSc*[2];
Taryn Scott, MSc[2]; *Mohit Bhandari, MD, PhD, FRCSC*[2];
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Poster #46
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A Systematic Approach to Reamed Exchange Nailing for the Treatment of Aseptic Femur Nonunions: A Review of 60 Nonunions in 59 Patients Treated by a Single Surgeon

Eli A. Swanson, MD[1]; *Derek Bernstein, BS*[2]; *Eli Garrard*[3];
Dan O'Connor, PhD[4,5]; ***Mark Brinker, MD***[1,4];
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[2]*Baylor College of Medicine, Houston, Texas, USA;*
[3]*Emory University Department of Orthopaedic Surgery, Atlanta, Georgia, USA;*
[4]*Fondren Orthopedic Group, Texas Orthopedic Hospital, Houston, Texas, USA;*
[5]*University of Houston, Houston, Texas, USA*

Poster #47
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Durability of Cephalomedullary Nail Fixation for Treatment of Metastatic Peritrochanteric Femoral Lesions

David H. Chafey, MD[1]; *Valerae O. Lewis, MD*[2]; *Robert L. Satcher, MD*[2];
Bryan S. Moon, MD[2]; *Patrick P. Lin, MD*[2];
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[2]*University of Texas-MD Anderson Cancer Center, Houston, Texas, USA*

Poster #48
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Omitting Preoperative Coagulation Screening in Fractured Neck of Femur Patients: Stopping the Financial Cascade?

Omer Salar, MRCS; Benjamin Baker, MBBS;
Benjamin Ollivere, FRCS (Tr & Ortho)*;*
Christopher G. Moran, FRCS (Tr & Ortho);
Queens Medical Centre, Nottingham, Nottinghamshire, England

Poster #49
(p. 373)

Quantitative Assessment of Femoral Head Perfusion Following Femoral Neck Fractures: An In Vivo Contrast-Enhanced MRI Study

Lionel E. Lazaro, MD[1]; *Jonathan P. Dyke, PhD*[2]; *Peter K. Sculco, MD*[1];
Jacqueline F. Birnbaum, BA[1]; *Keith Hentel, MD*[3]; *David L. Helfet, MD*[1];
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INJURY PREVENTION

Poster #50
(p. 376)

Vitamin D Deficiency in Orthopaedic Trauma

Jason P. Welter, DO[1]; *Thomas G. DiPasquale, DO*[2]; *Mark Richardson, MD*[2]; *Paul Muccino, DO*[2]; *Elizabeth Roth*[3];
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Poster #51
(p. 377)

Does Malnutrition in Patients Presenting With Fractures Predict Lower Quality Measures?

James H. Lee, BE; Lorraine H. Hutzler, BA; Brandon S. Shulman, BA; Raj J. Karia, MPH; ***Kenneth A. Egol, MD****;*
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Incidence and Risk Factors Associated With Deep Venous Thrombosis Among Hospital-Hospital Transfers with Pelvic and Lower Extremity Fractures

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Poster #53
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Gun Violence, Education, and the Orthopaedic Trauma Surgeon: A Model for Advocacy and Community Action

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A PCR-Based Protocol for Testing for Methicillin-Resistant *Staphylococcus aureus* (MRSA) Colonization in Orthopaedic Trauma Patients: Final Analysis

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KNEE and TIBIAL PLATEAU

Poster #55
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Lateral Fluoroscopic Projection Is Not Helpful in Judging Reduction of Tibial Plateau Fractures

Justin Haller, MD[1]; Robert O'Toole, MD[2]; Matt Graves, MD[3]; David Barei, MD, FCCS[4]; Michael Gardner, MD[5]; Erik Kubiak, MD[1]; Jason Nascone, MD[2]; Sean Nork, MD[4]; Angela Presson, PhD[1]; ***Thomas F. Higgins, MD[1]****;*
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Δ A Biomechanical Study of Posteromedial Tibial Plateau Fracture Stability: Do They All Require Fixation?

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Changing Presentation of Knee Dislocation With Vascular Injury in the Obese

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Tibial Plateau Fractures and Compartment Syndrome: When Should ORIF Be Performed?

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Poster #59
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Aquatic Weight Bearing for Periarticular Fractures Improves Function in the Near Term

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Poster #60 (p. 391)

A Prospective Study of Pain Reduction and Long-Term Knee Dysfunction Comparing Femoral Skeletal Traction and Splinting in Adult Trauma Patients

David B. Bumpass, MD; William M. Ricci, MD; Christopher M. McAndrew, MD; ***Michael J. Gardner, MD****;*
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OTHER

Poster #61 (p. 393)

Δ Time-Dependent Contamination of Open Irrigation Fluid in Orthopaedic Surgery

Thomas M. Jones, MD; ***Timothy J. O'Connor****; David Mikolajczyk; Paul A. Anderson, MD;*
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Poster #62 (p. 394)

Fact or Fiction for Penetrating Trauma: Is Follow-up Worse?

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Poster #63 (p. 395)

Fracture Pain Management in the Emergency Room: Is There a Bias?

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Can Fracture Surgical Skills Courses Improve Resident Performance?

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Treating the Trauma Knowledge Gap: A Validated Approach to Understanding Resident Knowledge and Addressing Deficiencies

Matthew Graves, MD[1]; Ebrahim Paryavi, MD, MPH[2]; Angela Faulhaber[3]; Mark C. Reilly, MD[4]; Michael Baumgaertner, MD[5]; ***Robert V. O'Toole, MD****[2];*
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Poster #66 (p. 399)

Clinical and Economic Impact of Duplicated Radiographic Studies in Trauma Patients Transferred to a Regional Trauma Center

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POSTERS

Poster #67 (p. 400)

The Intraoperative Interobserver Reliability of the Orthopaedic Trauma Association Open Fracture Classification Versus the Gustilo-Anderson Classification

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Poster #68 (p. 401)

Drilling Technique Can Minimize Plunging

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Poster #69 (p. 402)

• A Randomized, Double-Blind Pilot Study of Pregabalin as an Adjunct for Postoperative Pain Management in Orthopaedic Trauma Patients

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Poster #70 (p. 403)

Professional Demands and Stress in Orthopaedic Trauma: An Orthopaedic Trauma Association Member Survey

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Poster #71 (p. 405)

Does Radiation Exposure Affect Vision and Eye Health?

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Poster #72 (p. 406)

Body Site–Specific Fluoroscopic Radiation Exposure to the Orthopaedic Trauma Surgeon

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Poster #73 (p. 408)

Fluoroscopic Radiation to the Orthopaedic Traumatologist's Hand and Efficacy of a Novel Radiation-Attenuation Product

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PEDIATRIC

Poster #74 (p. 409)

The Effects of Restraint Type on Pattern of Spine Injury in Children

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Poster #75 (p. 410)

Functional Outcome of Supracondylar Elbow Fractures in the Pediatric Age Group: A 3-5–Year Follow-up

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Poster #76 (p. 411)

Pediatric Talar Fractures: Clinical Outcomes and Complications

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PELVIS and ACETABULUM

Poster #77 (p. 413)

Cell Saver Use in Acetabular Surgery: Does Approach Matter?

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Poster #78 (p. 414)

Is Preoperative XRT as Effective as Postoperative XRT for the Prevention of Heterotopic Ossification in Acetabular Fracture Patients?

***Michael T. Archdeacon, MD, MSE**; Albert d'Heurle, MD; Nicole Nemeth, MD; Bradley Budde, MD;*
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Poster #79 (p. 415)

Anatomic Determinants of Sacral Dysmorphism and Implications for Safe Iliosacral Screw Placement

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It's the Corridor Height Limiting Safe Transsacral Implant Positioning

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Poster #81 (p. 419)

Functional Outcomes in Women Following Pelvic Ring Fractures

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Poster #82 (p. 421)

Radiographic Follow-up of APC-II Pelvic Ring Injuries Treated With Symphyseal Plating and Iliosacral Fixation

Timothy B. Alton, MD[1]; *Andrew L. Merritt, MD*[1]; *Milton L. Routt Jr., MD*[2]; *Sean E. Nork, MD*[1]; *Michael J. Gardner, MD*[3]; *James C. Krieg, MD*[1];
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Poster #83 (p. 423)

The Effect of Pelvic Embolization on Wound Complications After Surgically Treated Pelvic and Acetabular Fractures

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Poster #84 (p. 425)

Incidence of Pelvic Arterial Bleeding and Complications in Patients Requiring Embolization and Pelvic/Acetabular Surgery

Pavel Muradov, MD; *Lisa Husak, MPH; Armen Martirosian, MD; Eric Lindvall, DO;*
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Poster #85 (p. 426)

Anatomical Relationship Between the Superior Gluteal Vessels and Nerve at the Greater Sciatic Notch: Implications for Controlling Hemorrhage During Surgery

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A Survey of High-Energy Acetabular Fractures in Elderly Patients

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Poster #87
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Femoral Nerve Palsy After Pelvic Fractures Treated With Anterior Internal Fixator: A Previously Unreported and Potentially Devastating Complication

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Inguinal Abnormalities in Male Patients With Acetabular Fractures Treated Using an Ilioinguinal Exposure

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POLYTRAUMA

Poster #89
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Δ Prevalence of Abuse and Intimate Partner Violence Surgical Evaluation (PRAISE): A Multinational Screening Study in Orthopaedic Fracture Clinics

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Poster #90
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Blowing Smoke: A Meta-Analysis of the Effects of Smoking on Fracture Healing and Postoperative Infection

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Poster #91
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Open Femoral Shaft Fractures: A Difficult Problem in Capable Hands

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Poster #92
(p. 434)

Obesity Is Associated With More Complications and Longer Hospital Stays After Orthopaedic Trauma

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SCIENTIFIC POSTERS

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Acute Blood Transfusion Is Associated With Pulmonary Complications in the Orthopaedic Trauma Patient

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Poster #94
(p. 437)

Muscle Viability Revisited: Are We Removing Normal Muscle? A Critical Evaluation of Dogmatic Débridement

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POST-TRAUMATIC RECONSTRUCTION

Poster #95
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Osseointegration as a Viable Treatment Option for Rehabilitation of Amputees

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Poster #96
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Split-Thickness Skin Grafts for Residual Limb Coverage and Preservation of Amputation Length

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Poster #97
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Retrograde Nailing of Distal Femur Periprosthetic Fractures: Malunion by Design?

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Poster #98
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Initial Injury Severity and Social Factors Determine Ability to Redeploy After Amputation

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SPINE

Poster #99
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Shock as a Risk Factor for Posttraumatic Stress Disorder Symptoms in Spine Trauma

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Poster #100
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Do Residents Know Evidence-Based Guidelines for Cervical Spine Clearance in Blunt Trauma Patients?

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TIBIA

Poster #101
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The Retrograde Tibial Nail: A New Implant Concept for Distal Tibia Fractures

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Poster #102
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Infection Rates Following Intramedullary Nailing of Open Tibial Shaft Fractures in Low- and Middle-Income Countries

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Distal Tibia Fractures and Medial Plating: Factors Influencing Reoperation

Jordan C. Apfeld, BA; Vasanth Sathiyakumar, BA; Harrison F. Kay, BS; Young M. Lee, BS; William T. Obremskey, MD, MPH; ***Manish K. Sethi, MD***;
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Poster #104
(p. 453)

Does the New OTA Classification for Open Fractures Predict the Risk of Lower Limb Amputation?

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Poster #105
(p. 454)

Semi-Elective Treatment of Open Tibial Shaft Fractures With Intramedullary Nail Fixation and Primary Wound Closure: Is it Safe?

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SCIENTIFIC POSTERS

UPPER EXTREMITY

Poster #106 (p. 455)

Regional Block Anesthesia Improves Outcome in Patients Undergoing Proximal Humerus Fracture Repair Compared to General Anesthesia

Kenneth A. Egol, MD; *Jordanna Forman, BA; Crispin Ong, MD; Raj Karia, MPH; Andrew Rosenberg, MD; Joseph D. Zuckerman, MD;*
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Poster #107 (p. 456)

Factors Influencing Infection Rates After Open Fractures of the Forearm

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Poster #108 (p. 457)

Does Outcome Justify Cost? A Comparison of Locked Plates and Nonlocked Plates for the Treatment of Simple Olecranon Fractures

Edward M. DelSole, BS; James H. Lee, BE; Kenneth A. Egol, MD; ***Nirmal C. Tejwani, MD***;
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Poster #109 (p. 458)

Determination of Clavicle Fracture Displacement Utilizing 3-D Fluoroscopy: A Radiographic Study

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Poster #110 (p. 459)

Outcomes After Plating of Olecranon Fractures: A Multicenter Evaluation

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Poster #111 (p. 461)

Factors Affecting Functional Outcome After Scapula Fractures

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Poster #112 (p. 462)

Prospective Comparison of Percutaneous Versus Open Technique for the Treatment of Clavicle Fracture Yields Decreased Anterior Chest Wall Numbness

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Poster #113
(p. 464)

Comparison of Outcomes After Triceps Split Versus Sparing Surgery for Extra-Articular Distal Humeral Fractures

Emmanuel M. Illical, MD, FRCSC; Andrew R. Evans, MD; Adam Wright, MD; Dana Farrell, BS; Peter A. Siska, MD; ***Ivan S. Tarkin, MD****;*
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Poster #114
(p. 465)

Quantitative Comparison of Exposure for the Posterior Judet Approach to the Scapula With and Without Deltoid Takedown

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WRIST and HAND

Poster #115
(p. 466)

Marginal or Rim Intra-Articular Fractures Involving the Volar Surface of the Distal Radius: A Descriptive Study

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Poster #116
(p. 467)

Dorsal Spanning Plate Fixation for Distal Radius Fractures in Polytrauma Patients

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Yale University School of Medicine, New Haven, Connecticut, USA

Poster #117
(p. 468)

Preexisting Osteoarthritis Does Not Affect Outcome in Distal Radius Fractures

Jonah Hebert-Davies, MD*; George-Yves Laflamme, MD; Dominique Rouleau;*
Hôpital Sacre-Coeur, Montreal, Quebec, Canada

Poster #118
(p. 470)

An Evaluation of Possible Prophylactic Therapies for the Prevention of Posttraumatic Joint Stiffness

Shawn Yeazell, BS*; Ben Keller, MS; Aaron Casp, BS; Paul Weinhold, PhD; Laurence E. Dahners, MD;*
Department of Orthopaedics, University of North Carolina, Chapel Hill, North Carolina, USA

Poster #119
(p. 472)

•Sustained Intra-Articular Delivery of IL-1Ra From a Thermally Responsive Polypeptide Depot Prevents Posttraumatic Arthritis in Mice

Kelly A. Kimmerling, MEng*; Bridgette D. Furman, BS; Daniel S. Mangiapani, MD; Michael A. Moverman; S. Michael Sinclair, MS; Janet L. Huebner, MS; Virginia B. Kraus, MD, PhD; Lori A. Setton, PhD; Farshid Guilak, PhD; Steven A. Olson, MD;*
Duke University Medical Center and Duke University, Durham, North Carolina, USA

• 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 496.

Poster #120
(p. 474)

Clinical Validation of an In Vivo Rat Model for the Study of Blast-Induced Heterotopic Ossification

Husain Bharmal, MD[1,2]; *Youngmi Ji, PhD*[1]; *Gregory Christopherson, PhD*[1]; *Thao Nguyen, MD*[3]; *Astor Robertson, MD*[3]; *Carl Cirino*[1]; *Wesley Jackson, PhD*[4]; *Vincent Pellegrini, MD*[3]; *Leon Nesti MD, PhD*[1,2,4];
[1]*Orthopaedic Research Group, National Institute of Arthritis and Musculoskeletal and Skin Diseases, National Institutes of Health, Bethesda, Maryland, USA;*
[2]*Department of Orthopaedics, Walter Reed National Military Medical Center (WRNMMC), Bethesda, Maryland, USA;*
[3]*Department of Orthopaedics, University of Maryland School of Medicine, Baltimore, Maryland, USA;*
[4]*Uniformed Services University of the Health Sciences, Bethesda, Maryland, USA;*

Poster #121
(p. 476)

Assessment of Osseous Incorporation of Endosteal Fibular Allograft Used to Augment a Fixation Construct for Femoral Neck Fractures: An In Vivo Magnetic Resonance Imaging Study

Lionel E. Lazaro, MD[1]; *Nadja A. Farshad-Amacker, MD*[2]; *Jonathan P. Dyke, PhD*[3]; *Jacqueline F. Birnbaum, BA*[1]; *David L. Helfet, MD*[1]; *Hollis G. Potter, MD*[2]; *Dean G. Lorich, MD*[1];
[1]*Orthopaedic Trauma Service, Hospital for Special Surgery and New York Presbyterian Hospital, Weill Medical College of Cornell University, New York, New York, USA;*
[2]*Division of Magnetic Resonance Imaging, Hospital for Special Surgery, New York, New York, USA;*
[3]*Citigroup Biomedical Imaging Center, Weill Medical College of Cornell University, New York, New York, USA*

Poster #122
(p. 478)

Determination of Relative Radiation Exposure From C-arm Fluoroscopy Views Taken During Orthopaedic Trauma Operations: A Pilot Study

Rita Baumgartner; *Omar Bakr; Anthony Ding, MD; Silas Marshall, MD; Saam Morshed, MD, PhD; Meir Marmor, MD;*
Department of Orthopaedic Surgery, University of California, San Francisco, San Francisco, California, USA

Poster #123
(p. 480)

Biomechanical Comparison of Locked Plating and Spiral Blade Retrograde Nailing in Osteoporotic Supracondylar Femur Fractures

Saqib Rehman, MD[1]; *Soroush Assari, MS*[2]; *Alan Kaufman, BS*[2]; *Kurosh Darvish, PhD*[2]; *Jung Park, MD*[1]; *Jonathan Haw, MD*[1];
[1]*Temple University Hospital, Philadelphia, Pennsylvania, USA;*
[2]*Temple University School of Engineering, Philadelphia, Pennsylvania, USA*

See pages 91 - 132 for financial disclosure information.

Poster #124
(p. 481)

An Innovative Culture System for the Study of Heterotopic Ossification
Husain Bharmal, MD[1,2]*; Gregory T. Christopherson, PhD*[1]*; Youngmi Ji, PhD*[1]*;*
Carl Cirino[1]*; Wesley M. Jackson, PhD*[3]*; Leon J. Nesti, MD, PhD*[1,2,3]*;*
[1]*Orthopaedic Research Group, National Institute of Arthritis and Musculoskeletal and Skin Diseases, National Institutes of Health, Bethesda, Maryland, USA;*
[2]*Department of Orthopaedics and Rehabilitation, Walter Reed National Military Medical Center, Bethesda, Maryland, USA;*
[3]*Uniformed Services University of the Health Sciences, Bethesda, Maryland, USA*

Poster #125
(p. 483)

A Safe Technique for Dynamizing the Taylor Spatial Frame
Christopher Iobst, MD[1]*; Anthony Khoury, BS*[2]*; Zachary Ingwer, BS*[2]*;*
David Kaimrajh, MS[3]*; Edward Milne*[3]*;* ***Loren L. Latta, PE, PhD***[2,3]*;*
[1]*Miami Children's Hospital, Coral Gables, Florida, USA;*
[2]*University of Miami, Coral Gables, Florida, USA;*
[3]*Max Biedermann Institute for Biomechanics, Miami Beach, Florida, USA*

Poster #126
(p. 485)

•Relationship of Intramuscular Tissue Oxygenation and Muscle Viability in a Compartment Syndrome Model
James Mok, MD; Heejae Kang, BS; Erik Hansen, MD; Hubert Kim, MD;
Utku Kandemir, MD*;*
Department of Orthopaedic Surgery, University of California San Francisco, San Francisco, California, USA

Poster #127
(p. 486)

Are Hook Plates Advantageous to Antiglide Plates for Vertical Shear Malleolar Fractures?
Daniel A. Jones, MD; J. Gary Bledsoe, PhD; ***Lisa K. Cannada, MD****;*
Saint Louis University Department of Orthopaedic Surgery, St. Louis, Missouri, USA

Poster #128
(p. 487)

Delivery of Jagged1 Immobilized to a Scaffold Stimulates MSC Osteoblast Differentiation
Michael Dishowitz, PhD*; Luke Lopas, BS; Jason Burdick, PhD;*
Jaimo Ahn, MD, PhD; Kurt Hankenson, DVM, PhD;
University of Pennsylvania, Philadelphia, Pennsylvania, USA

(p. 489)

BEST TRAUMA RELATED POSTER – 2013 ORS MEETING
Early Risk Stratification for Wound Specific Heterotopic Ossification Formation in Combat Casualties
Keith Alfieri[1, 2]*; Benjamin K. Potter*[1, 2]*; Thomas Davis*[2, 1]*;*
Trevor Brown[2, 1]*; Eric Elster*[2, 1]*; Jonathan Forsberg*[2, 1]*;*
[1]*Walter Reed National Military Medical Center, Bethesda, MD, USA;*
[2]*Naval Medical Research Center, Silver Spring, MD, USA*

• 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 496.

DISCLOSURE LISTING – ALPHABETICAL

Aaron, Daniel Louis	*(n-none)*	Poster #27
Abdelgawad, Amr A.	*(n-none)*	Case Presentation Faculty
Abghari, Michelle S.	*(n-none)*	Paper #58; Poster #40
Abousayed, Mostafa	*(n-none)*	Poster #9
Abraham, Christine	*(n-none)*	Paper #91
Adelved, Aron	*(n-none)*	Paper #35
Agarwal, Prakash	*(n-none)*	Poster #6
Agel, Julie	*(9-Orthopaedic Trauma Association – AO Foundation; Orthopaedic Trauma Association)*	Paper #69 Mini Symposia Moderator
Agnew, Samuel G	*(3B-Zimmer Fracture Delphi HealthCare Partners, Bacterin International; 3C-Accelero Health Care Partners: Orthopaedic Service Line Management Select International: Executive Search Firm; 7-eMedicine; 8-Journal of Trauma)*	Mini Symposia Faculty
Ahn, Jaimo	*(2-Synthes; 3B-Merck; Synthes; U&i; 9-AAOS; American Physician Scientists Association; Foundation for Orthopaedic Trauma; NBME; Orthopaedic Trauma Association)*	Paper #15 Posters #23, 28, 90 128
Akbary, Ktubuddin	*(n-none)*	Poster #6
Akers, Kevin S	*(n-none)*	Paper #22
Al Muderis, Munjed	*(n-none)*	Poster #95
Alemdaroglu, Kadir Bahadir	*(n-none)*	Paper #73
Alfieri, Keith.	*(n-none)*	Best Trauma Related Poster-ORS
Allmon, Christopher	*(n-none)*	Poster #58
Althausen, Peter	*(4-The Orthopedic Implant Company; 8-Journal of Orthopaedic Trauma; 9-OTA Fund Development Committee, OTA Nominating Committee, AAOS Subcommittee on Trauma)*	Posters #66, 110 Mini Symposia Faculty
Altman, Gregory T	*(n-none)*	Paper #96
Alton, Timothy B	*(n-none)*	Posters #21, 82
Anderson, Donald D.	*(4-FxRedux Solutions LLC)*	Paper #5
Anderson, Duane	*(n-none)*	Paper #20
Anderson, Matthew A	*(n-none)*	Paper #10
Anderson, Matthew J	*(n-none)*	Paper #11

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Anderson, Paul	*(1-Pioneer; Stryker; 3B-Aesculap; Pioneer Surgical; 3C-Expanding Orthopedics; SI Bone; Spatatec; Titan Surgical; 4-Expanding Orthopedics; Pioneer Surgical; SI Bone; Spartec; Titan Surgical; 8-Clinical Orthopaedics and Related Research; Journal of Bone and Joint Surgery - American; Journal of Orthopaedics and Traumatology; Journal of Spinal Disorders; Neurosurgery; Spine; Spine Arthroplasty Journal; 9-AAOS; ASTM; Lumbar Research Society; North American Spine Society; Spine Arthroplasty Society; Spine Section of AANS/CNS)*	Poster #61
Andreychik, Cassondra	*(n-none)*	Poster #17
Anglen, Jeffrey O.	*(8-Journal of the American Academy of Orthopaedic Surgeons; 9-AAOS; American Board of Orthopaedic Surgery, Inc.)*	Paper #12
Apfeld, Jordan C	*(n-none)*	Posters #8, 10, 32, 53, 103
Appelmann, Philipp	*(n-none)*	Poster #101
Appleton, Paul T	*(2-Acumed, LLC; 3B-Acumed LLC)*	Paper #79
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)*	Papers #60, 77; Poster #78; Mini Symposia Faculty
Archer, Kristin	*(n-none)*	Papers #91, 93
Armbruster, David	*(3A-DePuy Synthes)*	Paper #24
Arora, Shobha	*(n-none)*	Poster #6
Aschoff, H. H.	(*)	Poster #95
Assari, Soroush	*(n-none)*	Poster #123
Atupan, Jerome B	*(n-none)*	Paper #50
Awariyah, Dominic	*(n-none)*	Paper #71
Aydogan, Nevres H	*(n-none)*	Paper #73
Babb, Patricia	*(n-none)*	Posters #38, 71
Backus, Jonathon David	*(n-none)*	Paper #100
Bahney, Chelsea	*(5-Musculoskeletal Transplant Foundation; 8-European Cell and Matrix Journal)*	BSFF Moderator; BSFF Symposium Faculty
Baidoo, Paa Kwesi	*(n-none)*	Paper #71
Baker, Benjamin	*(n-none)*	Poster #48

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Baker, Kevin . . . . . *(n-none)* . . . . . Paper #19
Bakr, Omar . . . . . *(n-none)* . . . . . Poster #122
Baldwin, Keith . . . . . *(3B-Synthes Trauma; 4-Pfizer; 7-Journal of Bone and Joint Surgery - American)* . . . . . Posters #23, 90
Ballreich, Jeromie . . . . . *(n-none)* . . . . . Paper #88
Balthrop, Paul M . . . . . *(n-none)* . . . . . Paper #76
Barei, David P . . . . . *(2-Synthes; 3B-Synthes; 5-Zimmer; Synthes; 9-AO/ASIF)* . . . . . Posters #41, 55; Moderator; Mini Symposia Faculty; Lab Faculty
Barnhoorn, Karlijn J . . . . . *(n-none)* . . . . . Paper #104
Basmajian, Hrayr G. . . . . . *(n-none)* . . . . . Poster #70
Baumgaertner, Michael R. . . . . . *(9-AOTrauma: International Board North America representative AONA President)* . . . . . Poster #65
Baumgartner, Rita . . . . . *(n-none)* . . . . . Poster #122
Beaupre, Lauren A. . . . . . *(n-none)* . . . . . Paper #28
Bédard, Luc . . . . . *(n-none)* . . . . . Paper #81
Bedigrew, Katherine . . . . . *(6-Semprus Biosciences has provided coated k-wires for a study. Synthes provided plates for a study. Tornier provided plates for a study.)* . . . . . Poster #1
Beltran, Michael J . . . . . *(n-none)* . . . . . Paper #62
Belzile, Etienne . . . . . *(2-Ergoresearch, Bayer, Bristol-Myer-Squibbs, Stellar, Pfizer, 3B-Zimmer Inc, 5-CIHR, MSSS, Stryker, Novartis, Smith&Nephew, Lilly)* . . . . . Paper #81
Benirschke, Stephen K . . . . . *(3B-BESPA Inc.)* . . . . . Paper #69
Berg, Arthur . . . . . *(n-none)* . . . . . Paper #18
Bergin, Patrick . . . . . *(5-Synthes, Major Extremity Trauma Research Consortium (METRC))* . . . . . Lab Faculty
Bergman, Joseph . . . . . *(n-none)* . . . . . Paper #28
Berkes, Marschall B. . . . . . *(n-none)* . . . . . Papers #84, 85
Bernstein, Derek . . . . . *(n-none)* . . . . . Poster #46
Bernstein, Joseph . . . . . *(n-none)* . . . . . Poster #28
Berry, Gregory . . . . . *(n-none)* . . . . . Paper #44
Bethel, Monique . . . . . *(n-none)* . . . . . Paper #12
Betts, Robert F . . . . . *(n-none)* . . . . . Poster #54
Bevevino, Adam James . . . . . *(n-none)* . . . . . Poster #5
Bhandari, Mohit . . . . . *(3B-Amgen Co; Eli Lilly;Stryker; Smith & Nephew; Zimmer; Stryker; Moximed; Bioventus; 5-Smith & Nephew;* . . . . . Papers #38, 52; Posters #24, 45, 89

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Bhandari, Mohit (cont'd) .... *DePuy, A Johnson & Johnson Company; Eli Lily; Bioventus)*

Bharmal, Husain .... *(1-Dr. Pellegrini has an intellectual property agreement with Depuy Orthopaedics for total hip arthroplasty implants. These royalties are unrelated to the submitted research.)* ..... Posters #120, 124

Bible, Jesse .... *(8-Spine and The Spine Journal)* .... Paper #17; Poster #16

Binder, Ellen F .... *(n-none)* ....Paper #42

Birnbaum, Jacqueline F .... *(n-none)* ....Papers #84, 85; Posters #3, 49, 121

Bishop, Julius A .... *(1-Innomed; 2-Synthes; 5,6-Covidien)*...... Papers #48, 87; .... Poster #4

Blair, James A................ *(n-none)* .... Poster #1

Bledsoe, Gary................ *(n-none)* .... Poster #127

Blizzard, Sabina.............. *(n-none)* .... Poster #99

Bogdan, Yelena .... *(n-none)* ....Paper #41

Bonnaig, Nicholas............ *(n-none)* ....Paper #60

Born, Christopher T .... *(2-Stryker; 3B-Stryker; Illuminoss; DeRoyal; 3C-Biointraface; 4-Biointraface; Illuminoss; 5-Stryker; 9-American College of Surgeons; Orthopaedic Trauma Association; AAOS; Foundation for Orthopaedic Trauma)* ... Paper #49; ..... Poster #27

Borrelli, Jr, Joseph .... *(2-Eli-Lilly; 3B-Baxter Healthcare; Wright Medical Technologies, RTI, Synthes, Inc.; 6-Synthes, AO Trauma; 7-Elsevier, Springer-Verlag* .... BSFF Moderator

Bosse, Michael J.............. *(4-Orthopaedic Implant Company)* ..... Papers #56, 65, 90; ....Symposium Faculty

Bowen, Thomas R............ *(n-none)* .... Poster #17

Boyd, Alysse J .... *(n-none)* .... Poster #111

Boyer, Martin I............... *(3B-Acumed, LLC; OrthoHelix; 4-MiMedX; OrthoHelix; 7-American Society for Surgery of the Hand; Wolters Kluwer Health - Lippincott Williams & Wilkins; 9-American Society for Surgery of the Hand)* .... Mini Symposia Faculty

Brady, Megan................ *(n-none)* ....Paper #41

Bray, Timothy J .... *(2-Kaiser Permenente honorarium for annual trauma update; 3C-Anthem Orthopaedics, FlexFix, Orthopaedic Implant Company; 4-Anthem Orthopaedics, Orthopaedic Implant* .....Posters #66, 110 .... Mini Symposia Moderator

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Bray, Timothy J (cont'd)	*Company, FlexFix; 6-Renown Regional Medical Center-Fellowship Funding, COTA/OTA -Fellowship Funding ; 8-Orthopaedic Trauma Association, President 2010-2011; 9-Orthopaedic Trauma Association Board of Directors, Current)*	
Brinker, Mark R	*(3B-Biomet Consultant; 8-JOT Section Editor)*	Poster #46
Broderick, J Scott	*(2-AONA; 9-Orthopaedic Trauma Association; South Carolina Orthopaedic Association)*	Case Presentation Moderator; Mini Symposia Faculty
Brown, Thomas D	*(3B-Smith & Nephew; Winston & Strawn-Attorneys Zimmermann Reed-attorneys; 5-Musculoskeletal Transplant Foundation; 7-Journal of Bone and Joint Surgery - American; 8-Journal of Orthopaedics and Traumatology)*	Paper #5
Brown, Trevor	*(n-none)*	Best Trauma Related Poster-ORS
Browner, Bruce D	*(8-Wolters Kluwer Health – Lippincott Williams & Wilkins; 9-American College of Surgeons)*	Border Lecturer; Mini Symposia Faculty
Buck, Brian	*(n-none)*	Poster #13
Buckley, Richard E	*(n-none)*	Papers #28, 75
Budde, Bradley	*(n-none)*	Poster #78
Bumpass, David	*(n-none)*	Poster #60
Burden, Robert L	*(3A-Vivorte, Inc., 4-Vivorte, Inc.)*	Poster #35
Burdick, Jason	*(n-none)*	Poster #128
Byun, Young-Soo	*(n-none)*	Paper #99
Canadian Orthopaedic Trauma Society (COTS)	*(1-Zimmer, Stryker, 2-Biomet, Depuy, Etex, Smith & Nephew, Stryker, Synthes, Zimmer, KCI, 3A-none, 3B-Zimmer, Amgen Co, Eli Lilly, Stryker, Smith & Nephew, Wright Medical Technology Inc, Kuros, Synthes, Etex, 3C-none, 4-Traumis, 5-Synthes, Biomet, Zimmer, Smith & Nephew, Stryker, Depuy, KCI, Wright Medical Technology Inc., Canadian Institutes of Health Research-CIHR, Canadian Orthopaedic Foundation, National Institutes of Health-NIAMS & NICHD, Pfizer, Amgen Co, 6-Depuy, Smith & Nephew, Stryker)*	Papers #44, 75
Canete, Arturo C	*(n-none)*	Paper #50
Cannada, Lisa K	*(2-Smith & Nephew; 3B-Zimmer; 5-Arthrex, Inc; Smith & Nephew; 8-Orthopedics Today;*	Poster #127; Case Presentation Moderator; Mini Symposia Moderator;

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Cole, Peter A.	*(3B-Synthes <$10k/year; 4-BoneFoams Inc, LLC; 5- Synthes)*	Posters #13, 86, 114; Symposium Faculty;
Collinge, Cory A	*(1-Biomet; Smith & Nephew; Advanced Orthopedic Solutions, Synthes; 3B-Biomet, Stryker, and Smith&Nephew; 8-Journal of Orthopaedic Trauma; 9-Foundation for Orthopedic Trauma)*	Papers #38, 41, 49, 83; Posters #43, 85, 87; Mini Symposia Moderator; Mini Symposia Faculty
Considine, Perrin T	*(n-none)*	Poster #10
Cooke, Cameron	*(3B-Biomet)*	Paper #51
Coons, David A	*(n-none)*	Poster #85
Cornelius, Andrew L	*(n-none)*	Poster #17
Cote, Derrick O	*(n-none)*	Paper #6
Coughlin, Richard R	*(n-none)*	Paper #71
Cowley, R Adams	*(n-none)*	Paper #86
Creevy, William R	*(9-AAOS; Orthopaedic Trauma Association)*	Paper #66; Case Presentation Faculty; Mini Symposia Faculty
Criner, Seth H	*(n-none)*	Poster #20
Crist, Brett D	*(2-Medtronic; Sonoma; 3B-KCI; 4-Amedica Corporation; Orthopaedic Implant Company; 5-Medtronic; Sonoma; Synthes; Wound Care Technologies; 8-Journal of Orthopaedic Trauma; Journal of the American Academy of Orthopaedic Surgeons; Orthoinfo.org; 9-Mid-Central States Orthopaedic Society; Orthopaedic Trauma Association)*	Paper #95; Posters #2, 69; Mini Symposia Moderator
Cronin, Patrick K.	*(n-none)*	Poster #110
Cross, William W.	*(2-Synthes, AO North America; 3B-Zimmer)*	Paper #87
Cuellar, Vanessa G.	*(3B-Cytonics Corp., Dupuy Synthes Inc., Intralock Inc., 4-Cytonics Corp.)*	Poster #56
Cunningham, Brian P	*(n-none)*	Poster #70
Curtin, Catherine.	*(n-none)*	Paper #48
Cuthbert, Richard J	*(n-none)*	Paper #13
D'Heurle, Albert	*(n-none)*	Paper #77; Poster #78
Dahners, Laurence E.	*(1-Tornier)*	Poster #118
Daiello, Lori	*(3B-Eli Lilly)*	Poster #27

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Daniels, Alan H	*(n-none)*	Poster #27
Dart, Bradley	*(n-none)*	Paper #6
Darvish, Kurosh	*(n-none)*	Poster #123
Daubs, Gregory	*(n-none)*	Poster #59
Davidovitch, Roy	*(3B-Mako Surgical; Stryker)*	Papers #43, 58, 89, 92
Davis, Thomas	*(n-none)*	Best Trauma Related Poster-ORS
Dawson, John	*(n-none)*	Paper #37
Day, Jonathan D.	*(9-National Commission on Orthotic and Prosthetic Education)*	Mini Symposia Faculty
De Giacomo, Anthony	*(n-none)*	Paper #66; Poster #11
De Leon, Regidor B	*(n-none)*	Paper #50
Deaderick, Stuart	*(n-none)*	Paper #47
DeCoster, Thomas A	*(4-Merck; Pfizer; US Orthopedics; 7-Journal of Bone and Joint Surgery - American; 8-OKO; 9-AAOS; Orthopaedic Trauma Association)*	Moderator
Dehghan, Niloofar	*(n-none)*	Papers #46, 78; Mini Symposia Faculty
Dekkers, Mark	*(n-none)*	Paper #51
Della Rocca, Gregory J	*(2-Synthes; 3B-LifeNet Health; Intellectual Ventures; Synthes; Bioventus; 4-Amedica; The Orthopaedic Implant Company; MergeNet; 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; American College of Surgeons)*	Paper #95; Posters #2, 69; Mini Symposia Faculty
Delsole, Edward M	*(n-none)*	Poster #108
DePaula, Carl A	*(3A-DePuy Synthes)*	Paper #24
DeSilva, Gregory	*(4-Pfizer)*	Lab Faculty
Diaz-Granados, Paul	*(n-none)*	Paper #1
Dickens, Jonathan F	*(n-none)*	Poster #5
Diello, Lori	*(n-none)*	Poster #27
Ding, Anthony	*(n-none)*	Poster #122
Dionne, Carol P	*(9-NCOPE)*	Mini Symposia Faculty
Dipasquale, Thomas G	*(2-Synthes; 5-Stryker; Eli Lilly)*	Poster #50

Disclosure:
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Diponio, Lisa . . . . *(n-none)* . . . . .Paper #48
Dishowitz, Michael . . . . *(4-Co-founder of Skelegen)*. . . . . Paper #15; Poster #128
Vetrovec-Dobberstein, Diane. . . *(n-none)* . . . . OTA Staff
Dobson, Christopher Robert . . . *(n-none)* . . . . Posters #34, 36
Dodds, Seth D . . . . *(n-none)* . . . . Poster #116
Dolenc, Andrea . . . . *(n-none)* . . . . .Paper #32; Posters #92, 93
Donahue, Henry J . . . . *(n-none)* . . . . .Paper #18
Donegan, Derek J . . . . *(3B-Synthes)*. . . . . Poster #23
Doro, Christopher M . . . . *(n-none)* . . . . Moderator
Dougherty, Evan A . . . . *(5-BloXR)* . . . . Posters #72, 73
Dougherty, Paul J . . . . *(8-Clinical Orthopaedics and Related Research)* . . Poster #42
Dubina, Andrew . . . . *(n-none)* . . . . Poster #58
Dulai, Sukhdeep K . . . . *(9-Board of Directors of the COA Basic Science Course; Committee member of the Evidence based medicine committee of POSNA; Executive member of the Canadian Pediatric Orthopedic Group)* . . . . .Paper #28
Dungca, Daniel V . . . . *(n-none)* . . . . .Paper #50
Dungca, Godofredo V. . . . . *(n-none)* . . . . .Paper #50
Durfee, Ryan . . . . *(n-none)* . . . . Poster #105
Dworak, Theodora . . . . *(n-none)* . . . . Poster #5
Dyke, Jonathan P. . . . . *(n-none)* . . . . Posters #49, 121
Dziadosz, Daniel R . . . . *(2-Synthes; AO North America)* . . . . Lab Faculty
Ebner, Hannes L . . . . *(n-none)* . . . . .Paper #26
Egol, Kenneth A. . . . . *(1-Exactech, Inc; 3B-Exactech, Inc; 5-Synthes; OREF, OTA, OMEGA; 7-SLACK Incorporated; Wolters Kluwer Health – Lippincott Williams & Wilkins; 8-Journal of Orthopaedic Trauma)* . . . Papers #38, 43, 49, 58, 63, 67, 83, 89, 92, 101, 102; Posters #25, 40, 51, 56, 64, 106, 108, 115; BSFF Moderator; BSFF Symposium Faculty; Case Presentation Faculty
Ehrenfeld, Jesse M. . . . . *(n-none)* .Paper #86; Posters #8, 32
Ehrlichman, Lauren K . . . . *(n-none)* . . . . Poster #29
Einhorn, Thomas A . . . . *(1-Medtronic; 2-Bioventus; Medtronic; Merck; 3B-Anika; Medtronic; Bioventus; Harvest; 4-Biomineral Holdings; Healthpoint Capital; Implant Protection; NeoStem; 7-Elsevier; Journal of Bone and Joint Surgery - American;* . . . . .Paper #41

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DISCLOSURE LISTING – ALPHABETICAL

Einhorn, Thomas A (cont'd) . . . . . *Lippincott-Williams and Wilkins; 8-BONE; Journal of Bone and Joint Surgery - American; Journal of Bone and Mineral Research; Journal of Orthopaedic Research; JBJS Reviews)*

Eliezer, Edmund . . . . . *(n-none)* . . . . . Paper #21

Elkins, Jacob . . . . . *(n-none)* . . . . . Paper #5

Elliott, Kirsten . . . . . *(n-none)* . . . . . Paper #68

Elster, Eric . . . . . *(n-none)* . . . . . Best Trauma Related Poster-ORS

Engiles, Julie . . . . . *(n-none)* . . . . . Paper #15

Ernat, Justin . . . . . *(n-none)* . . . . . Poster #74

Ertl, Janos P . . . . . *(2-Stryker; Medtronic Sofamor Danek; 5- Synthes; Amgen Co)* . . . . . Papers #12, 49, 83; Mini Symposia Faculty

Ertl, William J . . . . . *(n-none)* . . . . . Papers #49, 83; Mini Symposia Moderator

Evans, Andrew R . . . . . *(2-Synthes; 8-Journal of Orthopaedic Traumatology)* . . . . . Poster #113

Evans, Jason M . . . . . *(n-none)* . . . . . Paper #94; Posters #7, 16

Farrell, Dana . . . . . *(n-none)* . . . . . Poster #113

Farshad-Amacker, Nadja A . . . . . *(n-none)* . . . . . Poster #121

Fasbender, Karel . . . . . *(n-none)* . . . . . Paper #75

Faulhaber, Angela . . . . . *(3A-Employee of AO)* . . . . . Poster #65

Fennema, Jordan . . . . . *(n-none)* . . . . . Paper #1

Fessenden, Megan . . . . . *(3A-Smith & Nephew)* . . . . . Paper #4

Ficke, James R . . . . . *(9-AAOS- Chair, Extremity War Injury Project Team; AAOS Central Program Committee; Society of Military Orthopaedic Surgeons; American Orthopaedic Association-Leadership Committee)* . . . . . Mini Symposia Faculty

Firoozabadi, Reza . . . . . *(n-none)* . . . . . Paper #38; Posters #77, 88

Forman, Jordanna . . . . . *(n-none)* . . . . . Poster #106

Forsberg, Jonathan . . . . . *(n-none)* . . . . . Posters #5, 96; Best Trauma Related Poster-ORS

Forte, Mary L . . . . . *(n-none)* . . . . . Paper #39

Forward, Daren P . . . . . *(n-none)* . . . . . Lab Faculty

Fras, Andrew R . . . . . *(n-none)* . . . . . Poster #7

Freiss, Darin . . . . . *(n-none)* . . . . . Case Presentation Faculty

Frisch, Nicholas B . . . . . *(n-none)* . . . . . Posters #34, 36

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Frolke, Jan Paul M. . . . . *(2-Stryker; 3B-Stryker; 7-Orthopedie Actueel; 8-Orthopedie Actueel)* . . . . . . Papers #30, 104

Fryzel, David . . . . *(n-none)* . . . . .Paper #18

Fu, Eric . . . . *(n-none)* . . . . Poster #52

Fufa, Duretti. . . . . *(n-none)* . . . . Mini Symposia Faculty

Furey, Andrew . . . . *(n-none)* . . . . Poster #75

Furman, Bridgette D . . . . *(n-none)* . . . . Poster #119

Futvoye, Matt. . . . . *(n-none)* . . . . Poster #41

Gage, Andrew . . . . *(n-none)* . . . . Poster #15

Galat, Daniel D . . . . *(n-none)* . . . . Paper #20; Poster #102

Gandhi, Jonathan . . . . *(n-none)* . . . . .Paper #18

Gao, Fei . . . . *(n-none)* . . . . .Papers #7, 9

Gardner, Michael J. . . . . *(3B-Synthes; DGIMed; Stryker; RTI Biologics; 5-Synthes; Smith & Nephew; 7-Wolters Kluwer Health - Lippincott Williams & Wilkins; 9-Orthopaedic Trauma Association)* . . . Papers #42, 49, 83, 100; Posters #38, 55, 60, 71, 79, 82; Mini Symposia Faculty; Case Presentation Faculty

Gardner, Stephen T . . . . *(n-none)* . . . . Poster #52

Gardner, Warren E. . . . . *(n-none)* . . . . .Paper #37

Garner, Matthew R . . . . *(n-none)* . . . . .Papers #84, 85

Garrard, Eli. . . . . *(n-none)* . . . . Poster #46

Garrigues, Grant . . . . *(2-Tornier; 3B-Tornier; 5-Zimmer; 6-DJ Orthopaedics; Zimmer)* . . . . .Paper #87 . . . . .Paper #33

Gary, Joshua L . . . . *(8-Wolters Kluwer Health - Lippincott Williams & Wilkins; 9-Orthopaedic Trauma Association)*

Gaski, Gregory E . . . . *(n-none)* . . . . .Paper #2

Geddes, Timothy . . . . *(n-none)* . . . . .Paper #19

Genelin, Konstantin . . . . *(n-none)* . . . . .Paper #26

Gennis, Elisabeth. . . . . *(n-none)* . . . . .Paper #82

Georgiadis, Andrew G . . . . *(n-none)* . . . . Poster #57

Gershtein, Shani . . . . *(n-none)* . . . . Poster #19

Gershon, Richard C. . . . . *(n-none)* . . . . .Symposium Faculty

Ghacham, Wael . . . . *(n-none)* . . . . Posters #34, 36

Gherebeh, Petra . . . . *(n-none)* . . . . Poster #42

Giannoudis, Peter V . . . . *(1-Biomet; 2-Synthes; Medtronic Sofamor Danek, Olympus Biotech; 3B-Synthes, Olympus Biotech; 3C-Amgen Co;* . . . . . . .Paper #13 . . . . . Posters #12, 14; . . . . BSFF Moderator

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DISCLOSURE LISTING – ALPHABETICAL

Giannoudis, Peter V (cont'd) . . . . *5-DePuy, A Johnson & Johnson Company; Synthes; 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)* . . BSFF Symposium Faculty

Gibbons, Steven D. . . . . *(n-none)* . . . . Paper #33

Gibula, Doug . . . . *(n-none)* . . . . Poster #104

Giles, Erica . . . . *(n-none)* . . . . Paper #27

Gissel, Hannah. . . . . *(n-none)* . . . . Poster #104

Gitajn, Ida Leah . . . . *(n-none)* . . . . Poster #9

Glassman, David . . . . *(n-none)* . . . . Paper #76

Glazebrook, Mark . . . . *(3B-DePuy, Linvatec, Smith et Nephew, Biomimetic Inc, Bioset Onc, Mimedx Inc, Wright, Cartiva Inc, 5-DePuy, Arthrex, Smith Nephew, Biomitic Inc, Bioset Inc, Mimedx Inc, Cartiva Inc, 8-Foot Ankle International, JBJS-Am, JBJS-Br, CORR)* . . . . Paper #81

Glick, Michael . . . . *(n-none)* . . . . Paper #27

Glinkowski, Wojciech Michal . . *(9-Polish Telemedicine Society)* . . . . Paper #55

Glott, Thomas . . . . *(n-none)* . . . . Paper #35

Gold, Stuart M . . . . *(2, 3B, 5-Smith & Nephew; Stryker; 5-Synthes, Zimmer)* . . . . Poster #83

Gorczyca, John T . . . . *(8-The Journal of Orthopaedic Trauma; 9-AAOS CME Committee)* . . . . . . Papers #40, 80, 98; Poster #54;
(8-The Journal of Orthopaedic Trauma; 9-AAOS CME Committee) . . . Case Presentation Faculty; Mini Symposia Faculty

Gordon, J Eric. . . . . *(1,3B-Orthopediatrics; 3B-Smith & Nephew; 9-Pediatric Orthopaedic Society of North America)* . . . . Case Presentation Faculty

Gordon, Wade T . . . . *(n-none)* . . . . Poster #5

Goulet, James A . . . . *(1-Zimmer; 4-Pioneer Surgical Technology; 9-American Orthopaedic Association; Orthopaedic Trauma Association; Michigan Orthopaedic Society)* . Mini Symposia Moderator

Grant, Kevin. . . . . *(n-none)* . . . . Paper #19

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Graves, Matt L . . . . *(2-Synthes; 3B-Synthes; 5-Synthes; Stryker; 8-Journal of Orthopaedic Trauma; 9-Orthopaedic Trauma Association Education Committee)* . . . . Posters #41, 55, 65 . . . . . . Moderator; . . . . Lab Leader

Groenewoud, Hans JMM . . . . . . *(n-none)* . . . . Paper #104

Gross, Jonathan M. . . . . *(n-none)* . . . . Papers #80, 98; Poster #54

Gross, Steven C . . . . *(n-none)* . . . . Paper #63

Guelcher, Scott A . . . . *(n-none)* . . . . Paper #22

Guilak, Fashid . . . . *(n-none)* . . . . Poster #119

Gullahorn, Leslie J. . . . . *(2,3B-Smith & Nephew)* . . . . Cramer Memorial Luncheon

Gustilo, Ramon B . . . . *(1, 3C, 4, 9-Dgimed Orthopedic Inc, Eden Prairie, Mn.; 3C, 4, 6, 9-Orthopaedic International, Inc-Philippines)* . . . . Paper #50

Guthrie, Stuart T . . . . *(9-Michigan Orthopaedic Society)* . . . . . . Posters #34, 36, 57

Guy, Pierre . . . . *(3B-Stryker; 4-Traumis; 5-Synthes; Stryker; DePuy, A Johnson & Johnson Company)* . . . . Paper #41; . . . . Moderator; . . . . Case Presentation Moderator

Hadiano, Adrian . . . . *(n-none)* . . . . Paper #98

Hagen, Jennifer Elizabeth . . . . . *(n-none)* . . . . Poster #21

Haidukewych, George J . . . . *(1-DePuy, A Johnson & Johnson Company; Biomet; 3B-Smith & Nephew; Synthes; DePuy, A Johnson & Johnson Company; 4- Orthopediatrics, Institute for Better Bone Health; 6-Synthes; 8-Journal of Orthopedic Trauma; 9-AAOS)* Posters #91, 94, ... 97, 105

Haines, Nikkole M . . . . *(n-none)* . . . . Papers #41, 65

Hak, David J. . . . . *(3B-RTI Biologics Baxter Invibio; 4-Emerge; 5-Synthes; Stryker; 8-Orthopedics; Journal of Orthopaedic Trauma; European Journal of Orthopaedic Surgery; 9-Orthopaedic Trauma Association, International Society for Fracture Repair)* . . . . Poster #104 . . BSFF Symposium Faculty

Hakansson, Nils . . . . *(n-none)* . . . . Paper #6

Hakeos, William M . . . . *(4-Sentio MMG)* . . . . Posters #34, 36

Hall, Jeremy A . . . . *(2-Stryker; Zimmer; 3B-Zimmer; 5-Pfizer; Zimmer; Synthes; Stryker; Smith & Nephew; Amgen Co; Biomimetic; 6-Pfizer; Zimmer; Synthes; Stryker; Smith & Nephew; Amgen Co)* . . . . Paper #46, 78

Haller, Justin . . . . *(n-none)* . . . . Papers #59, 61; Posters #55, 59

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DISCLOSURE LISTING – ALPHABETICAL

Hamam, Al Walid	*(5-Research support from Synthes for an unrelated project.)*	Poster #81
Hameed, Morad	*(2-Synthes)*	Mini Symposia Faculty
Hamula, Matthew	*(n-none)*	Poster #63
Hankenson, Kurt D	*(3B-Venenum; 4-Skelegen; 5-Synthes; Pharmaseq; 8-Journal of Bone and Mineral Research; Connective Tissue Research; 9-Orthopaedic Research Society; ACLAM; AALAS)*	Paper #15 Poster #128
Hansen, Erik	*(n-none)*	Poster #126
Hao, Jiandong	*(n-none)*	Poster #104
Haonga, Billy T	*(n-none)*	Paper #21
Hardy, S.K.	*(n)*	Paper #22
Harris, Mitchel B	*(9-North American Spine Society)*	Paper #87 Posters #22, 33, 52
Harvey, Edward J	*(5-Synthes; Eli Lilly; 7-Canadian Journal of Surgery; Journal of Bone and Joint Surgery – American; 8-Canadian Journal of Surgery, Journal of Orthopaedic Trauma; Journal of Bone and Joint Surgery - American; 9-Canadian Orthopaedic Association; Orthopaedic Research Society; Orthopaedic Trauma Association)*	Paper #44
Hasenboehler, Erik A	*(5-Synthes)*	Lab Faculty
Haughan, Joanne	*(n-none)*	Paper #24
Havel, Liska	*(n-none)*	Poster #99
Haw, Jonathan	*(n-none)*	Poster #123
Hayda, COL (ret) Roman A	*(2-AONA; 3C-BioIntraface; 8-Clinical Orthopaedics and Related Research; Journal of Bone and Joint Surgery - American; Journal of Orthopaedic Trauma.; 9-AAOS; Orthopaedic Trauma Association; METRC)*	Poster #27
Haythornthwaite, Jennifer	*(n-none)*	Paper #90
Hebert-Davies, Jonah	*(n-none)*	Poster #117
Heels-Ansdell, Diane	*(n-none)*	Poster #67
Heetveld, Martin J	*(n-none)*	Paper #52
Heins, Sara E	*(n-none)*	Papers #90, 91

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Helfet, David L	*(3C-OHK; Healthpoint Capital; Orthobond; TriMedics; OR International; 4-OHK Medical Devices; FxDevices)*	Papers #84, 85; Posters #3, 49, 109, 121
Henderson, Corey	*(n-none)*	Poster #104
Henley, M Bradford	*(1-Renovis; Zimmer; 2-Sharp Healthcare Foundation; 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)*	Mini Symposia Moderator
Hentel, Keith	*(n-none)*	Posters #3, 49
Herder, Lindsay	*(n-none)*	Paper #79
Herfat, Safa	*(n-none)*	Paper #3
Hesse, Daniel	*(n-none)*	Poster #87
Hiatt, Shane A	*(n-none)*	Poster #62
Hiesterman, Timothy G	*(n-none)*	Poster #13
Higgins, Thomas F	*(3B-Smith & Nephew; 9-Orthopaedic Trauma Association)*	Papers #14, 41, 59, 61; Posters #55, 59, 112; Moderator; Symposium Faculty; Case Presentation Faculty
Hill, Austin	*(n-none)*	Poster #66; Mini Symposia Faculty
Hill, Brian W	*(n-none)*	Posters #86, 114
Hiller, Paul M.	*(n-none)*	OTA Staff
Hinson, Julian K	*(n-none)*	Poster #10
Hintz, Adam	*(n-none)*	Posters #72, 73
Ho, Christine A	*(n-none)*	Mini Symposia Faculty
Hoegler, Joseph	*(2-Synthes)*	Posters #34, 36
Holland, Tai	*(n-none)*	Paper #71
Holt, David	*(n-none)*	Paper #61
Holtzman, Daniel J.	*(n-none)*	Paper #69

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Hooe, Benjamin	*(n-none)*	Posters #10, 32
Hopkins, Melanie L.	*(n-none)*	OTA Staff
Hopman, Maria TE	*(n-none)*	Paper #30
Horwitz, Daniel S	*(1-Biomet; 1, 2, 3B-DePuy, A Johnson & Johnson Company; 2, 3B- Stryker; 2, 5-Synthes; 8-Wolters Kluwer Health – Lippincott Williams & Wilkins; 9-AAOS, Foundation for Orthopaedic Trauma)*	Paper #41; Poster #17, 112
Hoshino, C. Max	*(n-none)*	Paper #54; Poster #83
Howell, Ronald	*(n-none)*	Poster #63
Hsu, Joseph R.	*(9-Limb Lengthening Research Society, BOD; Orthopaedic Trauma Association, Military Committee; The Major Extremity Trauma Research Consortium-METRC, Executive Committee; Skeletal Trauma Research Consortium-STReC, Director; AAOS, BOS Research Committee)*	Posters #1, 98
Huebner, Janet L	*(n-none)*	Poster #119
Humphrey, Catherine A	*(n-none)*	Paper #49, 80, 98; Poster #54
Hunter, Joshua G	*(n-none)*	Paper #80
Husak, Lisa	*(n-none)*	Poster #84
Hutchinson, Julie	*(n-none)*	Paper #94
Hutzler, Lorraine H.	*(n-none)*	Poster #51
Illical, Emmanuel M	*(n-none)*	Poster #113
Iltar, Serkan	*(n-none)*	Paper #73
Immerman, Igor	*(n-none)*	Poster #56
Ingwer, Zachary	*(n-none)*	Poster #125
Inkellis, Elizabeth	*(n-none)*	Poster #100
Iobst, Christopher	*(2-Smith & Nephew; 3B-Ellipse Technologies)*	Poster #125
Irgit, Kaan S	*(n-none)*	Poster #17
Isa, Ahaoiza Diana	*(n-none)*	Poster #75
Issar, Neil M	*(n-none)*	Paper #93
Jackson, Wesley	*(n-none)*	Posters #120, 124
Jahangir, A Alex	*(7-Springer; 9-Orthopaedic Trauma Association)*	Paper #94; Posters #8, 16, 53; Mini Symposia Faculty
Jain, Neel P	*(n-none)*	Poster #18

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James, Christopher . . . . *(n-none)* . . . . Paper #62; Poster #110
Janowicz, Jakub . . . . *(n-none)* . . . . .Paper #55
Jao, Abigail T . . . . *(n-none)* . . . . .Paper #50
Jawa, Andrew . . . . *(n-none)* . . . . .Papers #97, 105
Jenkins, Tyler . . . . *(n-none)* . . . . .Paper #95
Jenkinson, Richard J . . . . *(5-Zimmer; Synthes; Biomet)*. . . . . .Paper #78, 81
Jeray, Kyle J . . . . *(2-AONA/Synthes; 3B-Zimmer; 4-Emerge; 5-Synthes; 7-Journal of Bone and Joint Surgery - AmericanNewsletter; 8-Journal of Bone and Joint Surgery - American; Journal of Orthopaedic Trauma; 9-AAOS; American Orthopaedic Association; American Orthopaedic Association; Orthopaedic Trauma Association; South Carolina Orthopedic Association)* . . . . .Moderator; Mini Symposia Faculty
Jerjes, Waseem . . . . *(n-none)* . . . . Posters #12, 14
Ji, Youngmi . . . . *(n-none)* . . . . Posters #120, 124
Jo, Mark . . . . *(n-none)* . . . . Poster #71
Johnstone, Alan J . . . . *(2-Smith & Nephew; 9-International Society for Fracture Repair)*. . . . . .Paper #68
Jones, Clifford B. . . . . *(7-Journal of Bone and Joint Surgery-American trauma newsletter; 8-JBJS, JBJS Trauma Newsletter, Journal of Orthopaedic Trauma, Journal of Trauma, CORR, OCNA; 9-AOA Own the Bone Board, Mid American Orthopaedic Association Membership Committee, OTA Membership Chairman, OTA Health Policy Committee, Michigan Orthopaedic Society PAC Secretary)* . . . . . Papers #38, 41, 49, 74, 83; Poster #76; Moderator; Symposium Faculty; Mini Symposia Faculty; Case Presentation Moderator; Case Presentation Faculty; Poster Tour Guide
Jones, Daniel . . . . *(5-Arthrex, Smith & Nephew)* . . . . Poster #127
Jones, Elena . . . . *(n-none)* . . . . .Paper #13
Jones, Kevin B . . . . *(7-Spouse affiliation with Tallow Book, LLC)* . . . . .Paper #14
Jones, Thomas M . . . . *(n-none)* . . . . Poster #61
Juhnke, D. L. . . . . (*) . . . . Poster #95
Kacena, Melissa A . . . . *(n-none)* . . . . .Paper #12
Kadakia, Rishin J . . . . *(n-none)* . . . . .Paper #93
Kaimrajh, David . . . . *(5-Nutek Othopaedics, FxDevices, Depuy, Advanced Orthopaedic Solutions, TOBY Orthopaedics)* . . . . .Paper #1

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DISCLOSURE LISTING – ALPHABETICAL

Kain, Michael S	*(n-none)*	Paper #41; Poster #110
Kaiser, Scott P.	*(n-none)*	Paper #71; Poster #79
Kallen, Michael A	*(n-none)*	Paper #103
Kam, Check C	*(n-none)*	Paper #1
Kamer, Lukas	*(n-none)*	Posters #26, 80
Kandemir, Utku	*(2-AO North America; Stryker; 5-Biomet; Stryker; Synthes)*	Paper #3; Posters #87, 126; Case Presentation Moderator; Mini Symposia Moderator
Kang, Heejae	*(n-none)*	Poster #126
Kang, William	*(n-none)*	Poster #97
Kanlic, Enes	*(n-none)*	Case Presentation Moderator
Karia, Raj	*(n-none)*	Papers #67, 89, 92, 101 Posters #25, 51, 106, 115
Karkare, Nakul	*(n-none)*	Poster #50
Karunakar, Madhav A	*(8-JOT Editorial Board, 9-AAOS Trauma ICL Committee, OTA Fellowship Committee)*	Paper #56; Posters #30, 31
Kaufman, Alan.	*(n-none)*	Poster #123
Kay, Harrison F	*(n-none)*	Papers #86, 93; Poster #103
Kazemi, Namdar	*(n-none)*	Paper #77
Keijsers, Noël LW	*(n-none)*	Paper #52
Kellam, James F	*(n-none)*	Papers #5, 56
Keller, Ben.	*(n-none)*	Poster #118
Kennedy, Diana	*(n-none)*	Paper #51
Ketz, John P	*(5-Biomimetic)*	Paper #80, 98, Posters #11, 54
Khalil, Jad	*(n-none)*	Posters #34, 36
Khoury, Anthony	*(n-none)*	Poster #125
Kim, Hubert T	*(8-Knee)*	Poster #126
Kim, Jaehon Michael	*(n-none)*	Poster #52
Kim, Ji Wan	*(6-This study was supprted by the AOTrauma Asia Pacific Research Grants)*	Paper #99
Kim, Jung Jae	*(n-none)*	Paper #99
Kimmerling, Kelly	*(n-none)*	Poster #119
Kiner, Dirk W	*(n-none)*	Paper #37
King, Lloyd (Doug)	*(n-none)*	Paper #51
Kiraly, Laszlo N	*(3B Nestle Nutrition Consultant)*	Poster #99
Kirk, Kevin L	*(9-AOFAS committee member)*	Poster #1

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Klawitter, Marina . . . . *(n-none)* . . . . Paper #26
Kleweno, Conor. . . . . *(n-none)* . . . . Paper #88
Klomp, Frank PAJ . . . . *(n-none)* . . . . Paper #104
Knox, Jeffrey B . . . . *(4-Smith and Nephew Stock Owner)* . . . . Poster #74
Koech, Kiprono G . . . . *(n-none)* . . . . Paper #20
Koenig, Scott . . . . *(n-none)* . . . . Paper #82
Konadu, Peter . . . . *(n-none)* . . . . Paper #71
Konda, Sanjit R . . . . *(n-none)* . . . . Paper #58; Posters #25, 30, 31
Kottmeier, Stephen A . . . . *(n-none)* . . . . Moderator
Koueiter, Denise . . . . *(n-none)* . . . . Paper #19
Koval, Kenneth J . . . . *(1, 2, 3B-Biomet; 2-Stryker; 7-Wolters Kluwer Health - Lippincott Williams & Wilkins; 8-Journal of Orthopaedics and Traumatology; 9-AAOS; Orthopaedic Trauma Association)* . . . . . . Posters #91, 94, 97, 105
Kraus, Virginia B . . . . *(n-none)* . . . . Poster #119
Kreder, Hans J . . . . *(3B-Immediate family consultant for Synthes; 5-Synthes; Biomet; Zimmer; 7-Elsevier Publishing; AO North America; 9-Canadian Orthopaedic Association, AO Trustee)* . . . . . . Papers #46, 78; Poster #81
Krieg, James C . . . . *(1-SAM Medical;Synthes CMF; 3B-Synthes; Acumed, LLC; 4-Domain Surgical; Trice Medical Technologies; 8-Journal of the American Academy of Orthopaedic Surgeons)* . . . Paper #69; Posters #21, 82
Krueger, Chad A . . . . *(9-American Academy of Orthopaedic Surgeons: Co-Chair of the Orthoportal Resident Advisory Group, Former Resident Member of the AAOS Communications Cabinet, Texas Orthopaedic Association: Resident Representative to the Board of Directors; AAOS)* . . . . Paper #22; Poster #98
Krumrey, Jacqueline J . . . . *(n-none)* . . . . Poster #20
Kruppa, Christiane G . . . . *(n-none)* . . . . Paper #38; Poster #76
Kubiak, Erik . . . . *(3B-Synthes; Tornier; Zimmer; DePuy, A Johnson & Johnson Company; Medtronic; DJ Orthopaedics; 4-Connextions Medical, Inc.; OrthoGrid Technologies, Inc.; 5-Zimmer; 8-Journal of Orthopaedic Trauma; 9-Foundation for Orthopaedic Trauma)* . . . . . Papers #59, 61; Posters #55, 59, 112; Case Presentation Faculty
Kuhn, Sebastian U. . . . . *(n-none)* . . . . Poster #101

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DISCLOSURE LISTING – ALPHABETICAL

Kumah, Raphael . . . . *(n-none)* . . . . Paper #71

Kwon, John Y . . . . *(3B-Trimed)* . . . . Paper #79; Poster #9

LEAP Study Group . . . . *(5-National Institute of Arthritis and Musculoskeletal and Skin Diseases, National Institutes of Health, National Center for Complimentary and Alternative Medicine, Johns Hopkins Center for Injury Research and Policy and National Center for Injury Prevention and Control, Centers for Disease Control and Prevention)* . . . . Paper #90

Lack, William . . . . *(n-none)* . . . . Papers #5, 56, 65; Poster #30

Laflamme, George-Yves . . . . *(3B-Stryker)* . . . . Poster #117

Laflamme, Mélissa . . . . *(n-none)* . . . . Paper #81

Lamartina, Joey . . . . *(n-none)* . . . . Paper #105

Lane, Joseph M . . . . *(2-Amgen, Eli Lilly, Inc., Weber Chilcott; 3B-Amgen, CollPlant, Inc, Bone Therapeutics, SA, BioMimetics, DFine, Graftys; Zimmer; Eli Lilly; 4-Dfine, CollPlant; 5-Amgen Co; Eli Lilly; 9-Orthopaedic Research Society; Musculoskeletal Tumor Society; AAOS; Association of Bone and Joint Surgeons, AOA, ASBMR)* . . . Mini Symposia Faculty

Langford, Joshua . . . . *(3B-Stryker; 4-Institute for Better Bone Health, LLC)* . . . . Posters #94, 105; Lab Faculty

Lantry, Jacob. . . . . *(n-none)* . . . . Paper #40

Lareau, Craig Richard. . . . . *(n-none)* . . . . Poster #27

Large, Thomas M . . . . *(4-The Orthopaedic Implant Company)*. . . . . Paper #69

Latta, Loren L. . . . . *(3C-FxDevices, NuTek Orthopaedics, 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-Assoc. for the Rational Treatment of Fractures)* . . . . Papers #1, 2; Poster #125; BSFF Moderator; BSFF Symposium Faculty

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Lazaro, Lionel E. . . . . *(n-none)* . . . . .Paper #85; Posters #49, 121
Le, Theodore Toan. . . . . *(n-none)* . . . . Paper #77; . . . . Mini Symposia Faculty
Lebrun, Christopher T . . . . *(8-Journal of Orthopaedic Trauma; 9-Orthopaedic Trauma Association)* . . . . .Paper #87
Lee, Donald . . . . *(1-Biomet, 7-Elsevier, 8-Journal of Hand Surgery - Deputy Editor)* . . . . . . Poster #107
Lee, James H . . . . *(n-none)* . . . . Papers #67, 102; . . . . Posters #40, 51, 108
Lee, Mark A . . . . *(2-Synthes, Zimmer, AONA; 3B-Synthes, Zimmer, Biomet; 5-Synthes; 6-Synthes Fellowship Support; 9-Orthopaedic Trauma Association)* . . . . Papers #10, 11 . . . BSFF Symposium Faculty
Lee, Olivia C. . . . . *(n-none)* . . . . Poster #22
Lee, Young M . . . . *(n-none)* . . . . Paper #86; . . . . Posters #32, 53, 103
Leighton, Ross K . . . . *(1-Zimmer; 2-Biomet; DePuy, A Johnson & Johnson Company; Etex; Smith & Nephew; Stryker; Synthes; Zimmer; 3B-Etex; 5-Synthes; 6-DePuy, A Johnson & Johnson Company; Smith & Nephew; Stryker; 9-Canadian Orthopaedic Association; Orthopaedic Trauma Association)* . . . . .Papers #38, 83
Lenze, Eric J . . . . *(n-none)* . . . . .Paper #42
Les, Clifford . . . . *(3C-Advancee Equine Research Institute)* . . . Posters #34, 36
Leveille, Lise . . . . *(n-none)* . . . . .Paper #41
Lewis, Lambert . . . . *(n-none)* . . . . .Paper #43
Lewis, Valerae O . . . . *(5-Stryker; 8-Hindawi Publishing Corporation; Orthopedics Today; 9-AAOS; Western Orthopaedic Association)* . . . . Poster #47
Liddle, Kate . . . . *(n-none)* . . . . .Paper #71
Lin, Carol A . . . . *(n-none)* . . . . Paper #34, 64; . . . . Poster #67
Lin, Clifford . . . . *(n-none)* . . . . .Paper #25
Lin, Patrick . . . . *(5-Pfizer; 7-Springer)* . . . . Poster #47
Lin, Tony . . . . *(n-none)* . . . . .Paper #27
Lindtner, Richard Andreas. . . . . *(n-none)* . . . . .Paper #26
Lindvall, Eric . . . . *(3B-Renovis)* . . . . Poster #84

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DISCLOSURE LISTING – ALPHABETICAL

Liporace, Frank . . . . *(1-Biomet; 2-Biomet; Synthes; Stryker; Medtronic; 3B-Biomet; Medtronic; Synthes; Stryker; 3C-AO)* . . . Papers #89, 102; Lab Faculty; Mini Symposia Faculty

Litrenta, Jody . . . . *(n-none)* . . . . Papers #38, 83

Little, Milton T M . . . . *(n-none)* . . . . Papers #84, 85

Liu, Joseph . . . . *(n-none)* . . . . Poster #79

Lopas, Luke . . . . *(n-none)* . . . . Paper #15; Poster #128

Lorich, Dean G. . . . . *(n-none)* . . . . Papers #84, 85; Posters #3, 49, 109, 121

Lujan, Trevor . . . . *(4-Equity ownership in Genesis Fracture Care, Inc)* . . . . Paper #5

Lundy, Douglas W . . . . *(3C-Synthes; 4-Livengood Engineering; 8-Clinical Orthopaedics and Related Research; Journal of Orthopaedic Trauma; Orthopedics; 9-AAOS; American Board of Orthopaedic Surgery, Inc.; American College of Surgeons; Georgia Orthopaedic Society; Orthopaedic Trauma Association; Orthopaedic Trauma Association)* . . . . Paper #20; Mini Symposia Faculty

Luo, Wylie . . . . *(n-none)* . . . . Poster #27

Luttrell, Kevin . . . . *(n-none)* . . . . Poster #43

Maceroli, Michael . . . . *(n-none)* . . . . Paper #98

MacKenzie, Ellen J . . . . *(8-Injury; 9-National Trauma Institute)* . . . . . Papers #29, 90

MacLean, Jeffrey . . . . *(n-none)* . . . . Poster #68

Madsen, Jan Erik . . . . *(n-none)* . . . . Paper #35

Maerz, Tristan . . . . *(n-none)* . . . . Paper #19

Maitra, Sukanta . . . . *(n-none)* . . . . Paper #11

Makanji, Heeren . . . . *(n-none)* . . . . Poster #22

Mangiapani, Daniel S . . . . *(n-none)* . . . . Poster #119

Manson, Theodore T. . . . . *(n-none)* . . . . Paper #54; Poster #58

Marcano, Alejandro I . . . . *(n-none)* . . . . Papers #43, 58, 67, 92; Poster #115

Marcantonio, Andrew J . . . . *(9-New England Orthopaedic Society – Membership Chairman)* . . . . Poster #110

Marcucio, Ralph . . . . *(n-none)* . . . . Papers #7, 9; BSFF Moderator; BSFF Symposium Faculty

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Markel, David C . . . . *(1,2,3B,4-Stryker; 4-Novi Bone and Joint Center, Arbotetum Ventures; 5-Stryker; 8-Clinical Orthopaedics and Related Research; Journal of Arthroplasty; Journal of Bone and Joint Surgery - American; Osteoarthritis and Cartilage; 9-Michigan Orthopaedic Society, AAHKS, Mid America Ortho Assoc)* . . . . BSFF Symposium Faculty

Marmor, Meir. . . . . *(n-none)* . . . . Poster #68; Poster #122

Marsh, J Lawrence. . . . . *(1-Biomet; 3B-Orthohelix; 4-FxRedux; 7-Oxford Press; 9-American Board of Orthopaedic Surgery, Inc.; American Orthopaedic Association; Mid American Orthopadics; NBME; RRC-chair, orthopaedic surgery)* . . . . .Paper #5

Marshall, Lynn M . . . . *(n-none)* . . . . Poster #99

Marshall, Silas . . . . *(n-none)* . . . . Poster #122

Martin, Elizabeth. . . . . *(n-none)* . . . . .Paper #80

Martinez, Danny F . . . . *(n-none)* . . . . Poster #56

Martirosian, Armen K. . . . . *(n-none)* . . . . Poster #84

Masnovi, Michelle. . . . . *(n-none)* . . . . .Paper #72

Mathis, Shannon . . . . *(n-none)* . . . . Poster #107

Matityahu, Amir M. . . . . *(2-DePuy-Synthes, A Johnson & Johnson Company; 4-Anthem Orthopaedics, LLC; Anthem Orthopaedics VAN, LLC; PDP Holdings, LLC; 5-Stryker and DePuy-Synthes)* . . . . Poster #68

Mau, Elaine . . . . *(n-none)* . . . . .Paper #8

Mauffrey, Cyril. . . . . *(1-Royalties for Springer textbook; 5-Osteomed research grant 100,000 as PI plus AO, OTA, DoD pending applications; 7-Springer; 8-Editorial Board for Current Orthopaedic practice, The European Journal of Orthopaedic Surgery and Traumatology, Patient Safety in Surgery)* . . . . Poster #104

May, Addison K. . . . . *(5-GlaxoSmithKline, BHR Pharma LLC; 9-Surgical Infection Society)* . . . . .Paper #94

May, Collin J. . . . . *(n-none)* . . . . Posters #29, 33

Mayer, Emily . . . . *(n-none)* . . . . .Paper #70

McAndrew, Christopher M . . . . *(2-Synthes; 7-Journal of Bone and Joint Surgery - American)* . . . . Papers #42, 87, 100; . . . . Posters #38, 60, 71; . . . . Mini Symposia Moderator

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McClellan, Trigg	*(3C-Skeletal Kinetics, LLC, Advanced Biologics Corporation, LLC; 4-Biomineral Holdings, LLC, Anthem Orthopaedics VAN, LLC, PDP Holdings, LLC, Total Connect Spine, LLC; 5-NuVasive, Stryker; 9-Northern California Orthopaedic Society)*	Poster #100
McDonald, Matthew R	*(n-none)*	Poster #8
McDowell, Susan M	*(n-none)*	Paper #12
McGonagle, Dennis.	*(n-none)*	Paper #13;
McKee, Michael D	*(1-Stryker; 2, 3B-Synthes; Zimmer; 5-Wright Medical Technology, Inc.; Zimmer; 7-Wolters Kluwer Health - Lippincott Williams & Wilkins; 8-Journal of Orthopaedics and Traumatology; 9-American Shoulder and Elbow Surgeons; Orthopaedic Trauma Association; Canadian Orthopaedic Association)*	Papers #46, 78; Moderator; Symposium Moderator; Mini Symposia Moderator; Symposium Faculty; Mini Symposia Faculty; Case Presentation Faculty; Lab Faculty; Poster Tour Guide
McKinley, Todd Owen	*(3B-Bioventus; 9-Orthopaedic Trauma Association)*	BSFF Symposium Faculty
McLaurin, Toni M	*(n-none)*	Paper #43; Poster #63
Meent, Henk	*(n-none)*	Paper #30
Mehler, Dorothea.	*(n-none)*	Poster #101
Mehlman, Charles T	*(3C-Stryker; 7-Oakstone Medical Publishing; 8-Journal of Bone and Joint Surgery - American; Journal of Orthopaedics and 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)*	Papers #70, 72
Mehta, Samir	*(2-Zimmer; ; Smith & Nephew; AO North America; 3B-Smith & Nephew; Synthes;. 5-Amgen Co; Medtronic; Smith & Nephew; 7-Wolters Kluwer Health - Lippincott Williams & Wilkins; 8-Current Opinion in Orthopaedics; 9-Pennsylvania Orthopaedic Society)*	Paper #87; Posters #23, 28, 90 Moderator; Mini Symposia Moderator; Mini Symposia Faculty; Case Presentation Faculty
Meritt, Andrew L.	*(n-none)*	Poster #82

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Merk, Bradley R.	*(2-Synthes; Stryker; 3B-Stryker; 5-Synthes; Stryker; 8-American Journal of Orthopedics; 9-Orthopaedic Trauma Association-Research Committee)*	Poster #18; Mini Symposia Faculty
Merrick, Michael	*(n-none)*	Paper #74
Merriman, David J	*(n-none)*	Paper #100
Merritt, Andrew	*(n)*	Poster #82
Messina, Michael	*(n-none)*	Poster #104
Meyer, Darlene A.	*(n-none)*	OTA Staff
Miclau, III, Theodore	*(3B-Amgen Co; Merck; Baxter; 5-Stryker; Synthes; 9-AO; Orthopaedic Research Society; Orthopaedic Trauma Association; Osteosynthesis and Trauma Care Foundation)*	Papers #7, 9 Moderator; Symposium Moderator; BSFF Moderator
Migneco, Mary	*(n-none)*	Poster #71
Mignemi, Nicholas	*(6-Isis Pharmaceuticals)*	Paper #17
Mikolajczyk, David	*(n-none)*	Poster #61
Milne, Edward	*(4-Stryker stock, 6-Advanced Orthopedic Solutions Inc, Toby Orthopedics LLC, Medtronic)*	Papers #1, 2; Poster #125
Miniaci-Coxhead, Sara Lyn	*(1-Arthrosurface, Zimmer, 2-Arthrosurface, 3B-Stryker, Arthrosurface, Zimmer, 4-Arthrosurface, Medtronic, Stryker, Smith & Nephew, Johnson&Johnson, 5-Stryker, Arthrex, DonJoy Orthopaedics, Smith and Nephew, 7-Lippincott, 9-American Shoulder and Elbow Surgeons; Arthroscopy Association of North America; American Orthopaedic Society for Sports Medicine; International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine)*	Paper #80
Mir, Hassan R.	*(3B-Smith & Nephew; 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; Foundation of Orthopaedic Trauma Nominating Committee)*	Papers #93, 94; Poster #16; Mini Symposia Faculty Lab Faculty

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DISCLOSURE LISTING – ALPHABETICAL

Mirza, Amer J.	*(2, 3B, 3C-Acumed, LLC; 3C-Seattle Information Systems)*	Poster #99; Case Presentation Moderator; Lab Faculty
Mitchell, Erika J	*(3B-Eli Lilly; 5-BloXR)*	Posters #72, 73
Mizerik, Kristin C	*(n-none)*	Poster #57
Mohanty, Khitish	*(n-none)*	Paper #75
Mok, James	*(5-Nuvasive)*	Poster #126
Molina, Cesar S	*(n-none)*	Paper #16; Posters #7, 107
Monga, Binit	*(n-none)*	Poster #6
Moon, Bryan S	*(n-none)*	Poster #47
Moore, David C	*(n-none)*	Poster #53
Moore, Sharon M.	*(n-none)*	OTA Staff
Moore, Timothy A	*(8-Journal of Bone and Joint Surgery - American)*	Papers #31, 32
Moran, Christopher G	*(2-Smith & Nephew DePuy-Synthes; 8-International Editorial Board, Injury; 9-British Orthopaedic Association)*	Poster #48
Morgan, Jordan H	*(n-none)*	Papers #33, 103; Posters #22, 52
Morgan, Steven J	*(4-Johnson & Johnson; Emerge Medical; 7-SLACK Incorporated; 8-Journal of Orthopaedic Trauma; 9-Orthopaedic Trauma Association, Western Orthopaedic Trauma Association)*	Paper #45
Morison, Zachary A	*(n-none)*	Paper #46
Morshed, Saam	*(3B-Microbion Corporation; 5-Stryker; Synthes)*	Paper #21; Posters #79, 122; BSFF Moderator; Symposium Faculty
Mosier, Brian	*(n-none)*	Paper #96
Moverman, Michael A	*(n-none)*	Poster #119
Muccino, Paul	*(n)*	Poster #50
Mukherjee, Kaushik	*(n-none)*	Paper #94
Mullis, Brian H	*(2-Synthes; 5-Amgen Co; Synthes; 8-Journal of Orthopaedic Trauma; 9-Orthopaedic Trauma Association)*	Paper #12, 49, 83; Poster #62; Mini Symposia Faculty
Mundi, Simran	*(n-none)*	Poster #24
Muradov, Pavel	*(n-none)*	Poster #84

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Murphy, Robert Francis .... *(n-none)* ....Paper #47
Murtha, Yvonne M .... *(9-AAOS)*................................Paper #95
Muschler, George F .... *(3B-FDA; 5-Medtronic,)* .... BSFF Symposium Faculty
Harvest Technologies, DSM)
Mutty, Christopher E .... *(n-none)* .... Poster #15
Mwachiro, Michael .... *(n-none)* ....Paper #20
Nahm, Nickolas.............. *(n-none)* .... Paper #31;
.... Poster #92
Nam, Diane .... *(2-Dupuy Synthes)* ....Paper #8
Nascone, Jason W .... *(1-Synthes; 3B-Smith & Nephew;* .... Posters #41, 55;
8-Journal of Orthopaedic Trauma; .... Lab Faculty
9-Orthopaedic Trauma Association)
Nauth, Aaron................ *(5-Synthes, Stryker;* .... Papers #25, 27, 78;
Sonoma Orthopaedics) .... BSFF Symposium Faculty;
.... Mini Symposia Faculty
Nemeth, Nicole .... *(n-none)* .... Poster #78
Nesti, Leon.................. *(n-none)* .... Posters #120, 124
Nguyen, Thao .... *(n-none)* .... Poster #120
Nicolescu, Raz .... *(n-none)* ....Paper #1
Nijhuis-Vandersanden, Ria .... *(n-none)* ....Paper #104
Nork, Sean .... *(2, 3B, 5-AONA, Synthes;* .... Paper #49;
3B-Amgen; 5-OTA) .... Poster #55
Noser, Hansrudi .... *(n-none)* .... Posters #26, 80
Nowotarski, Peter J........... *(1, 3B, 5-Synthes,* ....Paper #37
2-AO Trauma North America)
Nyman, Jeffry .... *(n-none)* ....Paper #17
Nypaver, Timothy J........... *(n-none)* .... Poster #57
O' Rear, Lynda............... *(6-material support from ISIS pharmaceutical)*....Paper #17
O'Connor, Daniel P .... *(3B-Nimbic, Inc., 3C-Nimbic, Inc.,* .... Poster #46
7-Slack, Inc.-author royalties)
O'Connor, Timothy J.......... *(n-none)* .... Poster #61
O'Mara, Timothy J............ *(2-AO North America; 4-Orthopaedic Implant* .. Poster #66
Company; 8-Journal of Orthopaedic Trauma;
9-AAOS)
O'Toole, Robert V .... *(3B-Smith & Nephew; 3C-IMDS;* .. Papers #33, 54, 87, 88;
5-Synthes; Stryker; .... Posters #41, 55, 58, 65
9-Orthopaedic Trauma Association) ....Moderator;
.... Case Presentation Faculty

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DISCLOSURE LISTING – ALPHABETICAL

Obremskey, William T	*(n-none)*	Papers #17, 36, 86, 91, 94; Posters #8, 10, 32, 103; Case Presentation Faculty; Poster Tour Guide
Oddone-Paolucci, Elizabeth	*(n-none)*	Paper #75
Oh, Chang-Wug	*(2-Synthes; 3C-Zimmer; 5-Synthes)*	Paper #99
Oh, Hyun-Cheol	*(n-none)*	Paper #53
Okike, Kanu	*(5-OREF; 5,6-DePuy, A Johnson & Johnson Company; 6-Zimmer; Stryker; Synthes)*	Papers #87, 103; Poster #22
Oliphant, Bryant	*(n-none)*	Poster #42
Ollivere, Benjamin	*(n-none)*	Poster #48;
Olson, Josh	*(n-none)*	Poster #13
Olson, Steven A	*(3B-Bioventus; 5-Smith & Nephew; Smith & Nephew; Synthes; 9-Southeastern Fracture Consortium)*	Poster #119; BSFF Moderator; BSFF Symposium Faculty; Mini Symposia Faculty
Ong, Crispin C.	*(n-none)*	Paper #101; Poster #106
Onuoha, II, Gerald	*(n-none)*	Poster #10
Ortega, Gilbert R	*(2-Smith & Nephew; 3B-Smith & Nephew)*	Poster #70; Moderator
Orton, Brannon	*(n-none)*	Poster #83
Osei, Daniel A	*(n-none)*	Mini Symposia Faculty
Osgood, Gregory M	*(3B-Synthes; Stryker; 5-Synthes; Stryker; Smith & Nephew; 8-Journal of Orthopaedics and Traumatology; 9-Orthopaedic Trauma Association; Foundation for Orthopaedic Trauma)*	Lab Leader
Ostrum, Robert F.	*(3B-Smith & Nephew, 8-Journal of Orthopaedic Trauma American Journal of Orthopaedics)*	Paper #49
Ota, Doug	*(n-none)*	Paper #48
Otlans, Peter	*(n-none)*	Paper #82
Ott, Susan M	*(n-none)*	Poster #21
Ouellette, Elizabeth Anne	*(2-Auxilium; 3B-Stryker, Synthes; 9-American Association for Hand Surgery; ASSH, Co-Chairman, Business of Hand Surgery Committee-2010-2013, Diversity Committee-2006-13, AO North America Hand Education Committee-2012-15, Florida Orthopedic Society, Program Committee Member-2012)*	Paper #1

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Pacheco, Wilfredo B .... *(n-none)* ....Paper #50
Pairon, Phillip .... *(n-none)* .... Poster #101
Palanca, Ariel................ *(7-The INVOS near infrared spectrography unit is on loan from Covidien)* ...... Poster #4
Pandanan, Joaquin C .... *(n-none)* ....Paper #50
Pankaj, Amite................ *(n-none)* .... Poster #6
Pape, Hans-Christoph .... *(3B-Zimmer; 7-Journal of Orthopaedic Research; Wolters Kluwer Health –Lippincott Williams & Wilkins; Springer; 8-J Orthop Trauma Injury; Open access emergency medicine)* ......BSFF Symposium Faculty
Pappas, Nick .... *(n-none)* .... Poster #107
Park, Jung.................. *(n-none)* .... Poster #123
Park, Kichul .... *(n-none)* ....Paper #99
Paryavi, Ebrahim............. *(n-none)* .... Paper #33; Poster #65
Patel, Sahaja .... *(3A,4-Vivorte, Inc.)* .... Poster #35
Patka, Peter .... *(n-none)* ....Paper #52
Payton, Alivia .... *(n-none)* ....OTA Staff
Pearl, Gary .... *(n-none)* .... Poster #94
Peindl, Richard .... *(n-none)* ....Paper #5
Pekmezci, Murat .... *(2-Orthofix, Inc.; Nuvasive; 5-Biomet; Nuvasive; Stryker)*................. Paper #3; Poster #100
Pelet, Stéphane.............. *(5-Arthrex Inc; Astra Zeneca, 9-Président Comité de DPC AOQ)* .... Paper #81; Symposium Faculty
Pellegrini, Vincent........... *(1-Dr. Pellegrini has an intellectual property agreement with Depuy Orthopaedics and receives royalties from implants used in total hip arthroplasty. This disclosure has no bearing on the currently submitted abstract.)* ... Poster #120
Perdue, Aaron M .... *(n-none)* ....Paper #94
Perez, Edward A .... *(2-Smith & Nephew; Zimmer, 3B-Biomet; Medtronic, 4-Bristol-Myers Squibb;. Pfizer; Stryker, 7-Saunders/, Mosby-Elsevier 9-Orthopaedic Trauma Association)* ....Paper #49; Lab Leader; Case Presentation Faculty
Petrie, Jeff .... *(n-none)* .... Poster #91
Petrisor, Brad .... *(2,3B,5-Stryker; 5-Zimmer; 6-Pfizer)* ....Paper #46

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DISCLOSURE LISTING – ALPHABETICAL

Petteys, Tim . . . . *(3A-Smith & Nephew)* . . . . .Paper #4

Phieffer, Laura S . . . . *(9-AAOS)* . . . . Papers #49, 83; . . . . Cramer Memorial Luncheon

Phillips, Donna . . . . *(n-none)* . . . . Poster #64

Pichetsurnthorn, Pie . . . . *(n-none)* . . . . .Paper #6

Podeszwa, David A. . . . . *(9-Pediatric Orthopaedic Society of North America; AAOS)* . . . . . . Mini Symposia Moderator

Polavarapu, Mahesh . . . . *(n-none)* . . . . Poster #18

Polfer, Elizabeth M . . . . *(n-none)* . . . . Poster #96

Pollak, Andrew N . . . . *(1-Extraortho; Zimmer; 5-Smith & Nephew; 7-AAOS; 9-National Trauma Institute)* . . . . .Papers #87, 88

Poon, Jeffrey . . . . *(n-none)* . . . . .Paper #75

Posner, Martin A . . . . *(n-none)* . . . . Poster #115

Possley, Daniel R . . . . *(n-none)* . . . . Poster #1

Potter, Benjamin . . . . *(5-Nanotherapeutics.; 9-Society of Military Orthopaedic Surgeons; AAOS-BOS – SOMOS - research)* . . Posters #5, 96 . . Best Trauma Related Poster-ORS

Potter, Hollis G . . . . *(3B-Smith & Nephew; 5-GE Healthcare; 8-Osteoarthritis and Cartilage)* . . . . . . Poster #121

Praet, Stephan FE . . . . *(n-none)* . . . . .Paper #52

PRAISE Investigators . . . . *(n-none)* . . . . Poster #89

Presson, Angela . . . . *(n)* . . . . Poster #55

Prieto, Edna Margarita . . . . *(n)* . . . . .Paper #22

Putnam, Brant . . . . *(n-none)* . . . . Poster #83

Putnam, Matthew D . . . . *(3B-Dynamic Clinical Systems; 3C-Dynamic Clinical Systems; 4-Eli Lilly; Merck; 5-Acumed, LLC; DePuy, A Johnson & Johnson Company; Stryker; Synthes; 8-Wrist; 9-American Society for Surgery of the Hand)* . . . . Lab Faculty

Quinnan, Stephen M. . . . . *(2-Smith & Nephew Orthofix; 3B-Smith & Nephew; Orthofix, Inc.)* . . . . . . .Paper #2

Ragel, Brian . . . . *(n-none)* . . . . Poster #99

Reddi, A Hari . . . . *(n-none)* . . . . Papers #10, 11

Rehman, Saqib . . . . *(2-Synthes; 3B-Eli Lilly Guidepoint Global; 5-Synthes; 7-Jaypee Medical Publishing; 8-Orthopedic Clinics of North America; 9-Pennsylvania Orthopaedic Society-Board* . . . Poster #123 . . . . . . Lab Faculty

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Rehman, Saqib (cont'd) . . . . *of Directors; Orthopaedic Trauma Association-Committee member)*

Reid, J Spence . . . . *(2, 3B-Smith & Nephew; 3B-Synthes; 8-Journal of Orthopaedics and Traumatology)* . . . . Paper #18; Mini Symposia Faculty

Reilly, Mark . . . . *(2-Synthes; Smith & Nephew; Stryker)* . . . . Poster #65

Reindl, Rudolph . . . . *(5-Synthes; 8-European Spine Journal)* . . . . Paper #44

Ren, Yupeng . . . . *(n-none)* . . . . Poster #18

Rhorer, Anthony S. . . . . *(2, 3B, 5-Smith & Nephew; 6-Synthes)* . . . . Lab Faculty

Ricci, William M . . . . *(1,3B,5-Smith & Nephew; 1,3B-Wright Medical Technology, Inc., 3B Biomet; Stryker; 7,8-Wolters Kluwer Health - Lippincott Williams & Wilkins, 8-Journal of Orthopaedic Trauma; 9-Orthopaedic Trauma Association, American Orthopaedic Association)* . . . . Papers #42, 49, 83, 100; Posters #38, 60, 71; Lab Faculty

Riccio, Anthony I. . . . . *(n-none)* . . . . Poster #74; Mini Symposia Faculty

Rich, Amy . . . . *(n-none)* . . . . Poster #94

Richard, Raveesh Daniel . . . . . . *(n-none)* . . . . Poster #17

Richards, Justin E . . . . *(n-none)* . . . . Paper #94

Richards, Peter J . . . . *(n-none)* . . . . Paper #26

Richardson, Mark . . . . *(n)* . . . . Poster #50

Riehl, John . . . . *(n-none)* . . . . Posters #91, 94

Ring, David C . . . . *(1,3B-Wright Medical Technology, Inc.;) (3B-Biomet; 4-Illuminos; 8-Clniical Orthopaedics and Related Research, Journal of Hand Surgery-American, Journal of Orthopaedic Trauma, Journal of Shoulder and Elbow Surgery; 9-American Shoulder and Elbow Surgeons, American Society for Surgery of the Hand)* . . . . Paper #97

Ringnes, Andrew . . . . *(n-none)* . . . . Paper #19

Roberts, Francis O . . . . *(n-none)* . . . . Poster #28

Robertson, Astor . . . . *(n-none)* . . . . Poster #120

Robertson, Daniel S. . . . . *(n-none)* . . . . Paper #95

Robidoux, Katie . . . . *(n-none)* . . . . Poster #27

Robinson, Juan De Dios . . . . *(n-none)* . . . . Paper #41

Rodericks, Deirdre . . . . *(n-none)* . . . . Paper #82

Rodriguez, Edward K. . . . . *(1-Zimmer; 4-MXO orthopedics; 5-Synthes)* . . . . Paper #79; Posters #29, 33

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DISCLOSURE LISTING – ALPHABETICAL

Roise, Olav	*(n-none)*	Paper #35
Romano, Desiree R	*(n-none)*	Paper #22
Rommens, Pol M	*(n-none)*	Posters #26, 80, 101
Rosenberg, Andrew	*(n-none)*	Poster #106
Rosenberg, Zehava S.	*(n-none)*	Poster #40
Rosenwasser, Melvin P	*(1-Biomet; 3B-Stryker; 8-American Journal of Orthopedics; 9-Osteosynthesis and Trauma Care Foundation)*	Lab Leader; Symposium Faculty
Roth, Elizabeth	*(n-none)*	Poster #50
Rothrock, Nan	*(7-Up To Date)*	Symposium Faculty
Rouleau, Dominique	*(n-none)*	Poster #117
Routt, Jr, Milton L "Chip"	*(n-none)*	Posters #77, 79, 82, 88
Rudloff, Matthew I	*(7-Saunders/Mosby-Elsevier)*	Lab Faculty
Russell, George V	*(2-AONA - Honorarium for two courses per year; Acumed, LLC; 3B-Acumed, LLC - Consulting fees; 4-Zimmer, Stock Options, <5%; 5-Synthes, Research Support, Salary support for research manager; METRC, research support; 8-Journal of Bone and Joint Surgery - American JBJS Newsletter Editor; 9-AAOS – BOC Committee Member; Orthopaedic Trauma Association - Research Committee Member; AAOS)*	Poster #41
Russell, Thomas A.	*(1-Smith & Nephew; 3A-Innovision, Inc; 4-ETEX, Innovision; 7-Wolters Kluwer Health - Lippincott Williams & Wilkins)*	BSFF Symposium Faculty
Russo, Scott S	*(2-DePuy)*	Paper #74
Ruth, John T	*(9-Orthopaedic Trauma Association)*	Moderator
Ryan, Scott P	*(n-none)*	Paper #33
Sagi, H Claude	*(1-Stryker; 2-Stryker; AO/Synthes; Smith & Nephew; 3B-Stryker; Synthes; Smith & Nephew; 5-Stryker; Smith & Nephew; Synthes; 8-Journal of Orthopaedic Trauma; 9-AAOS; Orthopaedic Trauma Association; Foundation for Orthopaedic Trauma)*	Papers #41, 62; Poster #110; Moderator
Sagy, Yael	*(n-none)*	Poster #19

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Sahu, Biswajit................ *(n-none)* ....Paper #57
Salai, Moshe................ *(n-none)* .... Poster #19
Salar, Omer................. *(n-none)* .... Poster #48
Salassa, Tiare .... *(n-none)* .... Poster #114
Sampson, Christopher .... *(n-none)* ....Paper #14
Sanchez, Carlos J .... *(n-none)* ....Paper #22
Sanders, David W .... *(3B,5-Smith & Nephew; 5- Synthes;* .... Papers #38, 41;
8-Wolters Kluwer Health - Lippincott Williams . .Moderator;
& Wilkins; 9-Orthopaedic ..... BSFF Symposium Faculty;
Trauma Association) .... Presentation Faculty
Sanders, Roy .... *(1-CONMED Linvatec; 1,2,3B,5-Biomet; Smith* Poster #11;
& Nephew; 2,5-Stryker; 2,3B,5-Medtronic;......Lab Leader
3B-DJO, Tenex; 5-Health and
Human Services; National Institutes
of Health-NIAMS & NICHD, METRC-DOD,
OTA; 7,8-Journal of Orthopaedic Trauma)
Saper, David................ *(n-none)* ....Paper #97
Sassoon, Adam .... *(n-none)* .... Posters #91, 94, 105
Satcher, Robert L .... *(9-AAOS)*.............................. Poster #47
Sathiyakumar, Vasanth........ *(n-none)* .... Paper #86;
.... Posters #8, 10, 32, 53, 103
Sathyendra, Vikram .... *(n-none)* ....Paper #18
Save, Ameya V.............. *(n-none)* .... Poster #116
Sawaguchi, Takeshi........... *(n-none)* .... Posters #26, 80
Sawardeker, Prasad.......... *(n-none)* ....Paper #1
Say, Ferhat .... *(n-none)* ....Paper #73
Scarcella, Nicholas R.......... *(n-none)* .... Poster #37
Schaer, Thomas .... *(3B-Medical Facets, Biomedflex; 3C-Formae;* .Papers #23, 24
4-Gentis; 5-Synthes; 9-AO Foundation)
Schemitsch, Emil H........... *(1,3B,6-Stryker; 3B-Amgen Co;* .... Papers #25, 27, 38,
Wright Medical Technology, Inc.; 41, 46, 78;
Kuros; 3B,5,6-Smith & Nephew; ....Moderator;
Research-CIHR; OMEGA; ...... Symposium Moderator;
Zimmer; Synthes; 7-Saunders/ ....BSFF Moderator;
Mosby-Elsevier; 8-Journal .... Symposium Faculty;
of Orthopaedic Trauma; ....Mini Symposia Faculty;
9-Orthopaedic Trauma Assoc.;. . BSFF Symposium Faculty;
Canadian Orthopaedic Association;
Osteosynthesis and Trauma Care Foundation)

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Schenker, Mara	*(n-none)*	Poster #90
Schmidt, Andrew H	*(1,3B-Smith & Nephew; 1-CFI Medical Solutions; 2,3B-Medtronic; 3B-AGA; 3C,4-Conventus Orthopaedics; 4-Anthem Orthopedics; International Spine and Orthopedic Institute.; 3C,4,5-Twin Star Medical; 7-Thieme, Inc.; 8-Journal of Orthopaedic Trauma; Journal of Knee Surgery; 9-Orthopaedic Trauma Association)*	Paper #34; Poster #67
Schnaser, Erik	*(n-none)*	Poster #37
Schneider, John	*(n-none)*	Poster #74
Schoenecker, Jonathan G	*(6-We get materials support from ISIS pharmaceutical.)*	Paper #16, 17
Schottel, Patrick	*(n-none)*	Papers #84, 85; Poster #3, 109
Schwartz, Herbert S	*(n-none)*	Paper #17
Scolaro, John A.	*(n-none)*	Poster #90
Scott, Taryn	*(n-none)*	Poster #45
Sculco, Peter K	*(n-none)*	Poster #49
Sems, Stephen A	*(1-Biomet)*	Poster #87; Mini Symposia Faculty
Sen, Milan K.	*(2-Stryker; Synthes; Smith & Nephew; 3B-Stryker; Synthes; Smith & Nephew; 5-Stryker; Synthes)*	Case Presentation Faculty; Mini Symposia Faculty
Service, Benjamin	*(n-none)*	Poster #97
Sethi, Manish K	*(n-none)*	Papers #86, 94; Posters #8, 10, 32, 53, 103; Mini Symposia Moderator; Mini Symposia Faculty
Sethi, Sanjiv	*(n-none)*	Poster #42
Setton, Lori A	*(n-none)*	Poster #119
Seymour, Rachel	*(n-none)*	Papers #56, 65; Posters #30, 31
Shabab-Uddin, Prof	*(6-Hospital receives free implants from Surgical Implant Generation Network (SIGN) and plates from Acumed*	Lab Faculty
Shafiq, Babar	*(n-none)*	Poster #13

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Shantz, Jesse A	*(5-Synthes)*	Papers #7, 9
Shearer, David	*(n-none)*	Paper #21
Shepard, Alexander D	*(n-none)*	Poster #57
Shields, Edward	*(n-none)*	Paper #98
Shin, Ryan	*(n-none)*	Paper #97
Shulman, Brandon S	*(n-none)*	Papers #89, 92, 101, 102; Posters #25, 51
Siegel, Judith	*(7-Wolters Kluwer Health - Lippincott Williams & Wilkins)*	Paper #49
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)*	Paper #74; Poster #76
Sims, Stephen A	*(5-Synthes for a current research project)*	Paper #56
Sinclair, S Michael	*(n-none)*	Poster #119
Singh, Jaswinder	*(n-none)*	Poster #6
Sinicrope, Brent	*(n-none)*	Poster #110
Siska, Peter	*(n-none)*	Poster #113
Sitte, Ingrid	*(n-none)*	Paper #26
Sivasubramaniam, Priya	*(n-none)*	Poster #16
Slobogean, Gerard P	*(8-Journal of Orthopaedic Trauma)*	Poster #45; Symposium Faculty; Mini Symposia Faculty
Smith, Casey	*(n-none)*	Paper #74
Smith, Charles E	*(n-none)*	Poster #93
Smith, Christopher S.	*(9-Orthopaedic Trauma Association)*	Poster #109
Smith, Wade R	*(3B-Synthes; Stryker; 7-Mcgraw Hill; 8-Journal of patient safety in surgery; 9-American College of Surgeons)*	Paper #45
Snoap, Tyler	*(n-none)*	Poster #76
Søberg, Helene L	*(n-none)*	Paper #35
Solberg, Brian D.	*(3B-Stryker)*	Poster #87
Song, Hyoung-kyeun	*(n-none)*	Paper #53
Soni, Nishant	*(n-none)*	Poster #6
Southeast Fracture Consortium	*(n)*	Paper #36

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DISCLOSURE LISTING – ALPHABETICAL

Southgate, Richard Douglas	*(4-Johnson & Johnson)*	Poster #54
Spiguel, Andre	*(n-none)*	Poster #71
Spitzer, Allison B	*(n-none)*	Poster #25
Sprague, Sheila	*(3A-Global Resarch Solutions Inc.; 4-Eli Lilly)*	Poster #45
Sprental, Nicole	*(n-none)*	Poster #15
SPRINT Investigators	*(n-none)*	Paper #64
Stafford, Paul R	*(6-AO North America – fellowship program support)*	Poster #88
Staeheli, John W	*(4-Abbott; DePuy, A Johnson & Johnson Company; Medtronic; Merck; Pfizer; Smith & Nephew; Stryker)*	Lab Faculty
Stahl, Daniel	*(n-none)*	Paper #41
Stannard, James P	*(2-Sonoma; Medtronic-Kyphon Products; Smith & Nephew; 3B-Sonoma; Smith & Nephew; Medtronic Sofamor Danek; 7-Theime; 8-Journal of Knee Surgery; 9-Orthopaedic Trauma Association)*	Paper #95; Posters #2, 69
Starman, James	*(n-none)*	Paper #56
Starr, Adam J	*(8-Editorial Board for Journal of Orthopaedic Trauma)*	Paper #33
Steinberg, Ely Liviu	*(n-none)*	Poster #19
Steins, Rogier	*(n-none)*	Paper #75
Stephen, David J	*(8-Journal of Bone and Joint Surgery – American; Journal of Orthopaedics and Traumatology)*	Paper #78
Stephens, Kyle R	*(n-none)*	Paper #20; Lab Faculty
Sterling, Robert	*(9-Member at Large, BoD, Maryland Orthopaedic Association; Chairman, AOA's Council of Orthopaedic Residency Directors; Member, AAOS Leadership Development Committee)*	Paper #39
Stewart, Suzannne	*(n-none)*	Paper #23
Stoneback, Jason W	*(n-none)*	Paper #45
Stover, Michael D	*(n-none)*	Posters #72, 73
Strauss, Eric J	*(n-none)*	Poster #64
Strauss, CDR Joseph E	*(n-none)*	Lab Faculty
Stubbart, James R	*(n-none)*	Paper #74

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Suarez, Paola . . . . *(n-none)* . . . . .Paper #48

Suk, Michael. . . . . *(3B-Stryker; Synthes; 6-Synthes; 8-American Journal of Orthopedics; Military Medicine; Journal of Trauma Management and Outcomes; 9-Orthopaedic Trauma Association; AO International)* . . . . Mini Symposia Moderator

Sullivan, Matthew P . . . . *(n-none)* . . . . Poster #23

Summers, Hobie . . . . *(3B-Olympus)* . . . . Posters #72, 73

Sundem, Leigh. . . . . *(n-none)* . . . . .Paper #98

Surace, Peter A. . . . . *(n-none)* . . . . Poster #111

Sutton, Daniel . . . . *(n-none)* . . . . Poster #32

Swafford, Rachel . . . . *(n-none)* . . . . .Paper #37

Swanson, Eli A. . . . . *(n-none)* . . . . Poster #46

Swellengrebel, Chris. . . . . *(n-none)* . . . . .Paper #97

Swenson, Alan K . . . . *(n-none)* . . . . Poster #77

Swiontkowski, Marc F . . . . *(2-Pfizer China; 7-Saunders/ Mosby-Elsevier; Wolters Kluwer Health - Lippincott Williams & Wilkins; 8-Journal of Bone and Joint Surgery - American; Journal of Bone and Joint Surgery - American)* . . . . . .Mini Symposia Faculty; Case Presentation Faculty

Switaj, Paul J . . . . *(n-none)* . . . . Poster #18

Switzer, Julie . . . . *(9-AAOS Women's Health Issues Advisory Board)* . . . . Poster #86

Sylvester, Steven . . . . *(n-none)* . . . . Poster #81

Szyld, Demian . . . . *(n-none)* . . . . Poster #64

Taitsman, Lisa A . . . . *(2-Smith & Nephew; 8-Journal of Orthopaedic Trauma; Geriatric Orthopaedic Surgery & Rehabilitation; 9-Orthopaedic Trauma Association; Residency Review Committee-ACGME Western Orthopaedic Association)* . . . . Paper #96; Poster #41

Takacs, Joel . . . . *(n-none)* . . . . .Paper #15

Takada, Naoya . . . . *(n-none)* . . . . Poster #44

Tan, Hiang Boon . . . . *(n-none)* .Paper #13; Posters #12, 14

Taormina, David P . . . . *(n-none)* . . . . Papers #63, 67, 101; . . . . .Posters #25, 115

Tarkin, Ivan S . . . . *(2,5-Synthes; Zimmer; 5-Pittsburgh Foundation)* . . . . Poster #113

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Teague, David C	*(8-Journal of Orthopaedics and Traumatology; 9-Center for Orthopaedic Trauma Advancement-COTA; Orthopaedic Trauma Association)*	Papers #49, 83
Tejwani, Nirmal C	*(1-Biomet; 2-Zimmer; Stryker; 3B-Zimmer; Stryker; 9-AAOS; Orthopaedic Trauma Association; Federation of Orthopaedic Trauma)*	Paper #43, 63; Posters #40, 63, 108
Templeman, David C	*(1-Zimmer; 3B-Baxter; Biomet; 3C-Orthofix, Inc.; 9-SIGN)*	Mini Symposia Faculty
Theologis, Alexander	*(n-none)*	Poster #100
Tiaden, André N	*(n-none)*	Paper #26
Tintle, Scott M	*(n-none)*	Poster #96
Torchia, Mike T	*(n-none)*	Poster #86
Tornetta, III, Paul	*(1-Smith & Nephew; 7-Wolters Kluwer Health - Lippincott Williams & Wilkins; 8-Journal of Orthopaedic Trauma)*	Paper #4, 38, 41, 49, 66, 82, 83, 105; Poster #110; Case Presentation Moderator; Symposium Faculty; Case Presentation Faculty; Poster Tour Guide
Tötterman, Anna	*(n-none)*	Paper #35
Toussaint, Rull James	*(n)*	Poster #9
Tran, Wesley H.	*(n-none)*	Poster #83
Tsahakis, James M	*(n-none)*	Paper #93
Tudu, Barsha	*(n-none)*	Paper #57
Turnbull, Nathan	*(n-none)*	Poster #97
Turner, Chad	*(n-none)*	Poster #62
Urrunaga, Nathalie H.	*(n-none)*	Paper #39
Vaidya, Rahul	*(5-Stryker Company, Kalamazoo, MI; 6-AO North America)*	Poster #42
Vallier, Heather A	*(8-Journal of Orthopaedics and Traumatology; 9-Orthopaedic Trauma Association)*	Paper #31, 32, 38; Poster #37, 92, 93, 111
van den Bekerom, Michel	*(n-none)*	Paper #81
Van De Meent, Henk	*(n-none)*	Paper #104
Van Dongen, Robert TM	*(n-none)*	Paper #104
Van Lieshout, Esther MM	*(n-none)*	Paper #52
Varecka, Thomas F	*(n-none)*	Lab Faculty

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Vicente, Milena (Lynn)	*(n-none)*	Paper #46
Vijay, Arun	*(n-none)*	Poster #6
Volberding, Paul	*(3B-BMS, Gilead; 7-Lippincott, Elsevier; 9-IAS-USA)*	BSFF Moderator
Volgas, David A.	*(5-Twin Star Medical)*	Paper #95; Posters #2, 69; Mini Symposia Faculty
Von Rechenberg, Briggitte	*(5-National Institutes of Health-NIAMS & NICHD; NCCR Co-Me of the Swiss National Science Foundation; Plus Orthopedics; Smith & Nephew; Synthes, 8-BMC Veterinary Science The Open Orthopedic Journal)*	Paper #26
Vongbandith, Tom.	*(n-none)*	Poster #64
Voor, Michael J	*(1-DePuy, A Johnson & Johnson Company; 3A,3B,4-Vivorte, Inc.; 3C-Aptis Medical; 5-Synthes; 8-Orthopedics; Journal of Bone and Joint Surgery - American; Clinical Orthopaedics and Related Research; SLACK Incorporated)*	Poster #35
Vrahas, Mark S.	*(3B-Synthes; 4-Pioneer Medical; 8-Clinical Orthopaedics and Related Research; 9-AO Foundation)*	Paper #103; Posters #22, 33; Symposium Moderator
Vrana, Kent E	*(n-none)*	Paper #18
Wagner, Daniel	*(6-Partial funding was received from Synthes GmbH, Solothurn, Switzerland)*	Posters #26, 80
Walker, Peter S	*(n-none)*	Poster #56
Wang, Manyi	*(n)*	Guest Nation Presentation
Wang, Yufa	*(n-none)*	Paper #8
Ward, Michael	*(n-none)*	Paper #6
Watkins, Amelia C.	*(n-none)*	Paper #39
Watson, J Tracy	*(1-Biomet; DePuy, A Johnson & Johnson Company; Smith & Nephew 2-Medtronic; Stryker; 3B-Bioventus; Smith & Nephew; 3C-Accelalox; Ellipse; 8-ortho knowledge online; 9-Orthopaedic Trauma Association)*	BSFF Symposium Faculty; Poster Tour Guide
Weatherford, Brian M	*(n-none)*	Poster #18
Weaver, Michael J	*(2-Synthes)*	Paper #33; Posters #33, 52

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Webb, Lawrence Xavier	*(2-Musculoskeletal Transplant Foundation; 3B-Zimmer; 6-Synthes; Smith & Nephew; Stryker; Kinetic Concepts, Doctors Group; 9-Orthopaedic Trauma Association, Southeastern Fracture Consortium Foundation)*	BSFF Symposium Faculty
Weber, Donald	*(n-none)*	Paper #28
Weber, Timothy G	*(n-none)*	Lab Faculty
Wegener, Stephen	*(8-Editor of Rehabilitation Psychology, 9-American Board of Rehabilitation Psychology)*	Papers #90, 91
Weinhold, Paul	*(n-none)*	Poster #118
Weinlein, John C	*(n-none)*	Paper #47; Lab Faculty
Weiss, David B	*(5-Smith & Nephew)*	Lab Faculty
Weiss-Meilik, Ahuva	*(n-none)*	Poster #19
Wellman, David S	*(3B-Synthes Dynamic Locking Screw; Synthes)*	Poster #109
Welter, Jason P	*(n-none)*	Poster #50
Wenke, Joseph C	*(8-Tissue Engineering Journal of Surgical Orthopaedic Advances)*	Paper #22; Poster #98; BSFF Moderator
West, John R	*(1-CONMED Linvatec; 6-CONMED Linvatec)*	Poster #15
Westberg, Jerald	*(n-none)*	Paper #34
Wetzel, Robert	*(n-none)*	Poster #18
Whetstone, Heather	*(n-none)*	Paper #8
White, Brian	*(n-none)*	Paper #76
White, Timothy O	*(3B, 5, 6-Acumed, LLC)*	Case Presentation Faculty
Whiting, Paul S	*(n-none)*	Paper #20; Poster #102; Lab Faculty
Williams, Joel C	*(n-none)*	Papers #10, 11
Williams, John	*(n-none)*	Poster #44
Williams, Mike	*(3A,3B-The Abaris Group)*	Mini Symposia Faculty
Wilson, Jr, Frederic B.	*(9-AAOS, SIGN)*	Lab Faculty
Wilson, Matthew	*(n-none)*	Posters #30, 31
Wilssens, Jean Pierre	*(3A- paid employee at RSscan)*	Paper #52
Wimberly, Robert L	*(n-none)*	Poster #74; Mini Symposia Faculty
Wolenski, Matthew	*(n-none)*	Poster #11

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Wolinsky, Philip R. . . . . *(2-Zimmer; 3B-Biomet; Zimmer; 8-Journal of Orthopedic Trauma; 9-OTA, AAOS, AOA, ACS)* . . . . Mini Symposia Faculty; Case Presentation Faculty
Won, Yougun . . . . *(n-none)* . . . . Paper #53
Woodbury, Ronald . . . . *(n)* . . . . Paper #22
Wooley, Paul. . . . . *(n-none)* . . . . Paper #6
Wright, Adam . . . . *(n-none)* . . . . Poster #113
Wright, David M . . . . *(n-none)* . . . . Poster #86
Wyrick, John D. . . . . *(3B-Stryker)* . . . . Paper #77
Xin, Guo . . . . *(n-none)* . . . . Poster #18
Yacob, Alem . . . . *(n-none)* . . . . Poster #116
Yang, Arthur. . . . . *(6-We are using a near infrared spectrography machine supplied by Covidien for our research.)* . . . . Poster #4
Yang, Kyu-Hyun . . . . *(1-Zimmer)* . . . . Paper #53
Yannascoli, Sarah. . . . . *(n-none)* . . . . Poster #90
Yeazell, Shawn . . . . *(n-none)* . . . . Poster #118
Yeboah, Dominic . . . . (*) . . . . Paper #71
Yengo-Kahn, Aaron. . . . . *(n-none)* . . . . Paper #86
Yi, Paul . . . . *(n-none)* . . . . Paper #97
Yoo, Brad J . . . . *(5-Synthes; 8-Journal of Orthopaedics and Traumatology)* . . . . Lab Faculty
Yoo, Jung U . . . . *(1-Yes, Osiris Therapeutics)* . . . . Poster #99
Yu, Yan Yiu . . . . *(n-none)* . . . . Papers #7, 9
Yuasa, Masato . . . . *(n-none)* . . . . Papers #16, 17
Zekaj, Mark . . . . *(n-none)* . . . . Poster #42
Zhang, Li-Qun . . . . *(n-none)* . . . . Poster #18
Zielinski, Stephanie. . . . . *(n-none)* . . . . Paper #52
Zienkiewicz, Katarzyna J . . . . . . *(n-none)* . . . . Paper #22
Zimel, Melissa N . . . . *(n-none)* . . . . Paper #19
Zinar, Daniel N . . . . *(n-none)* . . . . Poster #83
Ziran, Bruce H . . . . *(3B-Synthes; 4-Powers Medical Group, 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; 9-AAOS, American Board of Orthopaedic Surgery, Inc., American College of Surgeons, Orthopaedic Trauma Association)* . . . Mini Symposia Faculty

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Ziran, Navid M	*(n-none)*	Poster #85
Zirkle, Jr, Lewis G	*(3C-SIGN; 8-Orthoprenour; 9-Orthopaedic Trauma Association-International Committee)*	Poster #102; Lab Leader
Zonno, Alan	*(n)*	Paper #49
Zuckerman, Joseph D	*(1-Exactech, Inc; 4-Hip Innovation Technology; Neostem; 6-Orthonet; 7-SLACK Incorporated; Wolters Kluwer Health - Lippincott Williams & Wilkins; 9-American Orthopaedic Association; Musculoskeletal Transplant Foundation; Orthopaedic Research and Education Foundation)*	Paper #101; Poster #106
Zumsteg, Justin	*(n-none)*	Poster #107
Zura, Robert D	*(2, 3B-Smith & Nephew, Bioventus; 5-Synthes; 6-Synthes fellowship);*	Lab Faculty
Zusman, Natalie L.	*(n-none)*	Poster #99

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BSFF SYMPOSIUM 1:
HOT TOPICS IN BIOMECHANICS: HIP FRACTURE FIXATION

Moderators: *Steven A. Olson, MD*
Loren L. Latta, PE, PhD

7:30 am **Fixation Recommendations in 2013: Intramedullary Nailing**
Emil H. Schemitsch, MD

7:42 am **Fixation Recommendations in 2013: Plating**
Steven A. Olson, MD

7:54 am **Selecting the Best Model: Comparing Existing Devices to New Constructs**
Loren L. Latta, PE, PhD

8:06 am **Perspectives on the State of the Art - Where Are Improvements Needed?**
Thomas A. Russell, MD

8:18 am Discussion

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 496.

Scapholunate and Lunotriquetral Ligament Injuries Associated With Distal Radius Fractures: The Effect of Wrist Position and Forearm Rotation During a Fall Onto an Outstretched Hand

Razvan Nicolescu, MD[1]; *Elizabeth Anne Ouellette, MD, MBA*[2]; *Paul Clifford, MD*[1];
Check C. Kam, MD[3]; *Prasad J. Sawardeker, MD*[4]; *David N. Kaimrajh, MS*[5];
Edward L. Milne, BS[5]; *Jordan L. Fennema, MD*[6]; *Paul A. Diaz-Granados, MD*[7];
Loren L. Latta, PE, PhD[1,5];
[1]*University of Miami, Miami, Florida, USA;*
[2]*Physicians for the Hand, Coral Gables, Florida, USA;*
[3]*Indiana Hand to Shoulder Center, Indianapolis, Indiana, USA;*
[4]*University of North Dakota, Fargo, North Dakota, USA;*
[5]*Max Biedermann Institute for Biomechanics, Mt. Sinai, Miami Beach, Florida, USA;*
[6]*University of Michigan, Ann Arbor, Michigan, USA;*
[7]*University of Florida, Gainesville, Florida, USA*

Background/Purpose: The prevalence of scapholunate (SL) and lunotriquetral (LT) ligament injury with distal radius fractures can be as high as 54% and 20%, respectively. This unique in vitro biomechanical model simulated 4 different fall mechanisms: external rotation (ER) with neutral hand position, ER with ulnar deviation (UD), internal rotation (IR) with neutral hand position, and IR with radial deviation (RD) to evaluate if hand position and forearm rotation during a fall can influence whether an LT ligament tear occurs or not.

Methods: Fluoroscopic images, MRI scans, and dual energy x-ray absorptiometry (DEXA) bone mineral density measurements of the wrist were obtained for 48 fresh frozen cadaveric arms. Arms were transected 18 cm proximal to Lister's tubercle and then mounted at 80° of wrist extension and full pronation. In the first set of 24 arms, 8 were mounted perpendicular to the materials testing system (MTS) table top, 8 were RD 10° to 15°, and 8 were UD 10° to 15°. In the second set of 24 arms, 12 underwent 5 N-m of ER, with 6 of the arms perpendicular to the MTS table top and the other 6 UD 10° to 15°. The last 12 arms underwent 5 N-m of IR, with 6 of the arms perpendicular to the MTS table top and the other 6 RD 10° to 15°. The arms were then loaded on an MTS machine and axially displaced 2.5 cm at a compression rate of 5 cm/sec. Postinjury fluoroscopic images and MRI scans of the wrist were obtained and analyzed.

Results: All of the arms sustained a distal radius fracture. Post-test MRI revealed that 17 (35%) of the arms sustained an SL ligament tear, and 16 (33%) sustained an LT ligament tear. Of the 24 arms that did not undergo a rotational force, 5 (21%) sustained an SL or LT ligament tear. In contrast, of the 24 arms subjected to a rotational force, 18 (75%) were found to have either a SL or LT tear (Figure 1).

Discussion: SL and LT ligament tears were found to be associated with distal radius fractures in 75% of arms subjected to a rotational force, whereas only 21% of the arms with a static forearm displayed such an injury. Further investigation is needed to determine if a specific fall pattern is associated with an SL or LT tear.

See pages 91 - 132 for financial disclosure information.

Significance: Practitioners should maintain a high suspicion of SL or LT injury in patients who sustain a distal radius fracture after a fall onto an outstretched hand, particularly when forearm rotation is involved.

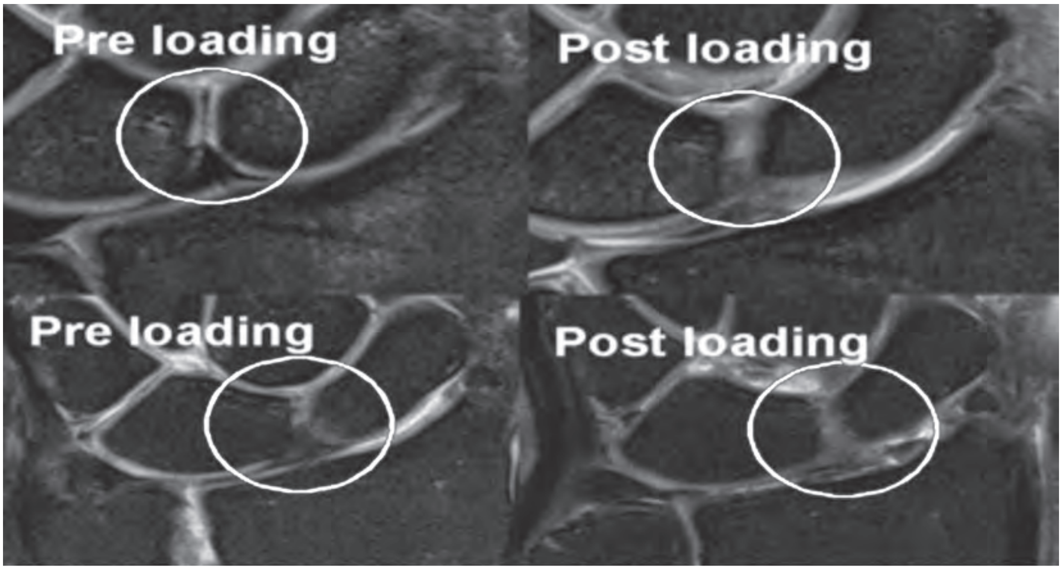

Fig. 1 ER arms with intact SL preloading had 50% tears (top); 75% of those with preexisting tears progressed (bottom).

PAPER ABSTRACTS

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Biomechanical Analysis of Far Proximal Radial Shaft Fracture Fixation

*Gregory M. Gaski, MD[1]; **Stephen M. Quinnan, MD**[1]; David Kaimrajh, MS[2]; Edward L. Milne, BS[2]; Loren L. Latta, PE, PhD[1,2];*
[1]Department of Orthopaedics, University of Miami, Miami, Florida, USA;
[2]Max Biedermann Institute for Biomechanics, Miami Beach, Florida, USA

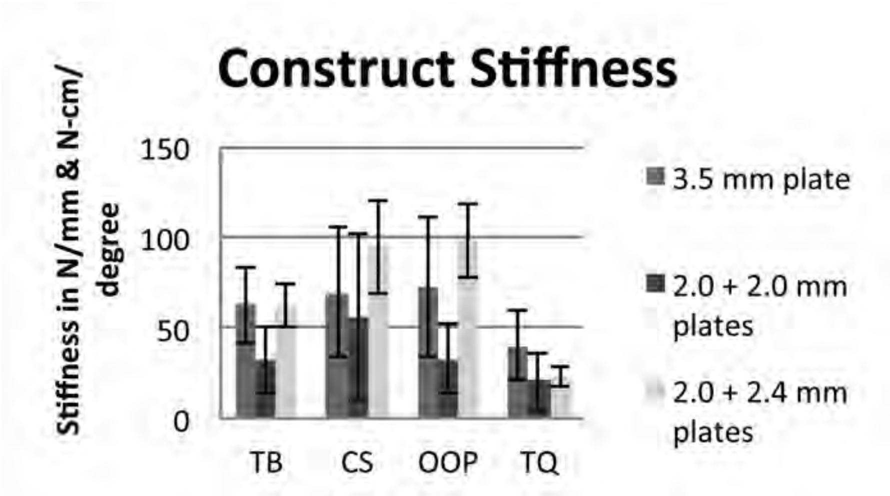
Background/Purpose: Fractures of the proximal radius pose a unique challenge in obtaining proximal fixation without disrupting ligamentous complexes of the elbow or limiting forearm rotation. Metaphyseal bone available for screw purchase is limited proximally by the annular ligament and medially by the bicipital tuberosity. We hypothesize that orthogonal plating with lower-profile mini-fragment plates will reduce the problems of impingement with forearm rotation while providing equal or greater construct stiffness and strength than traditional 3.5-mm plates.

Methods: In 5 fresh cadaver elbows, a transcondylar 2.0-mm horizontal reference wire was inserted through the elbow and a second parallel wire inserted through the radial styloid with the forearm fully supinated. Through a volar approach preserving all soft-tissue structures, with the arm in full supination, 2.0-mm, 2.4-mm, 2.7-mm, and 3.5 mm plates were applied to the volar surface of the proximal radius. The forearm was ranged through an arc of pronosupination without and then with implants. Impingement was observed when pronation of the radius led to contact with a one millimeter wire resting on the volar/radial surface of the ulna. Next, 11 matched pairs of formalin-fixed, human cadaveric radii were harvested and stripped of soft-tissue attachments. Bone mineral density for each group was 0.632 g/cm^2. A transverse osteotomy was created 2 cm distal to the bicipital tuberosity. Group 1 (G1) was affixed with a 5-hole 3.5-mm nonlocking plate with 2 bicortical screws proximal to the osteotomy and 3 bicortical screws distal; group 2 (G2), a 10-hole 2.0-mm nonlocking plate volarly and a 2.0-mm plate radially, both with 3 bicortical screws proximal and distal to the osteotomy; and group 3 (G3), a 2.4-mm plate volarly and a 2.0-mm plate radially. Specimens were loaded and stiffness measured for bending in 3 different planes: with the volar plate in tension band mode (TB), 90° out-of-plane mode (OOP), and on the compression side (CS). Next, torque stiffness (TQ) was measured and the constructs were loaded to failure. Groups were compared by multiple comparison analysis of variance.

Results: All specimens exhibited 90° of supination and a mean of 71° of pronation. There was no impingement observed with the 2.0-mm plate. The 2.4-mm plate construct reduced pronation by 19.5%; the 2.7-mm plate, by 43.7%; and the 3.5-mm plate, by 60.3%. In torsion, there were no significant (NS) differences in stiffness between any of the constructs. In bending stiffness, there was NS difference between G1 and G3 in TB or CS, but in OOP, G3 was greater than G1 (P <0.05). In TB and OOP, G2 constructs were less than G1 (P <0.0001 and 0.005), and G3 (P <0.001 and 0.0001). In CS, G2 was not significantly different from G1.

Conclusion: Orthogonal plating with low-profile 2.4-mm and 2.0-mm plates in the proximal radius is at least as stiff as a single 3.5-mm plate while avoiding significant mechanical impingement with forearm rotation.

See pages 91 - 132 for financial disclosure information.



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No Difference in Fatigue Failure Between Nonlocked and Locked Interlocking Screws of Intramedullary Nails in Proximal Tibia Fractures

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Department of Orthopaedic Surgery, University of California San Francisco, San Francisco, California, USA

Background/Purpose: The optimal type of fixation for proximal tibia fractures is still controversial. The fixation with intramedullary nailing usually fails with backing out of interlocking screws. In order to improve fixation failure, a new nail has been designed with interlocking screws being locked into the nail. The goal of this study is to compare the in situ fatigue strength of a new locking intramedullary nail (LN) with proximal fixed-angle interlocking screws to standard nonlocked (not fixed-angle) nails (NLN) in proximal tibia comminuted extra-articular fractures.

Methods: 6 pairs of fresh-frozen osteoporotic cadaveric tibias (age: 68.7 ± 4.6 [standard deviation] years; T-score: –2.7 ± 1.1) were used. One tibia from each pair was fixed with an LN while the contralateral side was fixed with a nonlocked nail (NLN). A gap model was created simulating a proximal tibia extra-articular severely comminuted fracture (OTA Type 41-A3.3). Specimens were cyclically loaded under compression, simulating the single leg stance phase of gait. Testing was conducted initially cycling between 100 N and 335 N (50% of average body weight) of compression. Every 20,000 cycles, the peak compression was increased by 10% of average body weight. Every 2500 cycles, localized gap displacements were measured with a 3-dimensional motion tracking system and planar x-ray images of the proximal tibia were taken. The two groups were compared using the following metrics: axial stiffness, failure load, number of cycles to failure, and mode of failure. To allow for mechanical settling, initial metrics were calculated at 2500 cycles. A paired *t* test (P <0.05) was used to determine statistical significance for all metrics.

Results: There were no significant differences in any metrics used to compare the LN and NLN. There was a difference in mode of failure with the LN failing primarily by the proximal screws cutting out the bone and the NLN failed primarily by the proximal screws backing out.

Nail Type	Initial Axial Stiffness (@2500 cycles)	Axial Stiffness (Just Before Failure)	Gap Subsidence (Medial, Lateral)	Failure Load	Cycles to Failure
LN	1244 ± 266 N/mm	1026 ± 292 N/mm	0.76 ± 0.44mm, 0.90 ± 0.50mm	1140 ± 310 N	212,500 ± 54,475
NLN	1172 ± 146 N/mm	928 ± 292 N/mm	1.14 ± 0.91mm, 1.10 ± 1.21mm	954 ± 256 N	180,000 ± 38,438

Conclusion: The results of this study suggest that while there is a trend for longer fatigue life, fixed-angle proximal locking screws of intramedullary nails for proximal fixation do not result in statistically different fatigue life when compared with the standard nail (NLN) in a comminuted, extra-articular proximal tibia fracture model.

See pages 91 - 132 for financial disclosure information.

Is Overdrilling of Cortical Screws an Appropriate Surrogate for Osteoporosis in Biomechanical Testing?

***Jacob L. Cartner, MS*[1]**; *Megan Fessenden, MS*[1]; *Tim Petteys, MS*[1]; *Paul Tornetta, III, MD*[2];
[1]*Smith & Nephew, Memphis, Tennessee, USA;*
[2]*Boston University Medical Center, Boston, Massachusetts, USA*

Background/Purpose: To simulate osteoporotic conditions, some authors have used a larger screw predrill in healthy bone by overdrilling 0.3 mm smaller than the major diameter in an attempt to decrease fixation strength and replicate failure modes of poor bone. However, use of this model has not been validated and all previous testing used plated constructs. The purposes of this study were to quantify the effect of overdrilling cadaveric bone on screw pull-out strength (POS) and stiffness and to evaluate the failure modes of construct testing using this method in surrogate bone models.

Methods: Matched pairs of human cadaveric femora and composite surrogate tibiae and femora were used for this study. *Phase One:* Cadaveric femoral shafts at progressive distances from the trochanteric tip received bicortical 3.5-mm or 4.5-mm screws orthogonal to bone. Screws were inserted after either a normal predrill based on manufacturer recommendation or an overdrill that was 0.3 mm smaller than screw major diameter (n = 40). Femora were resected into 40-mm segments. POS was measured using ASTM F543 standard testing. Tensile stiffness was also measured during pull-out. *Phase Two:* A comminuted metadiaphyseal fracture (OTA 41-A3) was simulated by creating a 1-cm proximal gap in composite tibiae. Two groups (n = 6 each) were plated with lateral proximal tibia plates using 3.5-mm locked or nonlocking diaphyseal screws after oversized screw predrills. The constructs were loaded in fatigue to 214 N using offsets both proximally and distally. *Phase Three:* A comminuted supracondylar fracture (OTA 33-A3) was simulated by creating a 2-cm gap in composite femora. Two groups (n = 6 each) were plated with lateral proximal femur plates with 4.5-mm locked or nonlocking diaphyseal screws after oversized screw predrills. The constructs were loaded in fatigue to 890 N using a 7° angle from the anatomic axis to the mechanical axis in the medial-lateral plane. Paired Student *t* tests were used in all phases.

Results: *Phase One:* Overdrilling the screw pilot hole decreased the POS of 3.5-mm screws by 53% (P <0.001), and 4.- mm screws by 76% (P <0.001). There were no differences in tensile stiffness for 3.5-mm (P = 0.67) or 4.5-mm screws (P = 0.25) when comparing the normal predrill to the overdrilled condition. *Phase Two:* All constructs failed via plate fracture near the gap. There were no differences in construct fatigue life (nonlocked: 97,935 cycles; locked: 98,886 cycles; P >0.64). *Phase Three:* All constructs failed via plate fracture near the gap. There were no differences in construct fatigue life (nonlocked: 66,496 cycles; locked: 67,195 cycles; P >0.57).

Conclusion: This study indicates that overdrilling healthy bone decreases screw POS, but does not affect tensile stiffness and may not mimic the failure modes of plated osteoporotic constructs seen clinically. Nonlocked constructs in poor quality bone have been reported to fail at the screw to bone interface, or by angular collapse from loosening, neither of which was observed in our findings. Additional work is needed to validate the overdrill model prevalent in the literature.

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Finite Element Analysis of the Distal Femur: Fracture Motion Predicts Clinical Callus

William Lack, MD; *Jacob Elkins, MS; Trevor Lujan, PhD; Richard Peindl, PhD; James Kellam, MD; Donald Anderson, PhD; Thomas Brown, PhD; J. Lawrence Marsh, MD; University of Iowa, Iowa City, Iowa, USA*

Background/Purpose: The biomechanical environment is theorized to affect bone healing; however, the optimal environment is poorly defined and surrogates are often studied in place of fracture gap motion. Finite element analysis (FEA) has successfully modeled the mechanical behavior of orthopaedic implants. We hypothesized that FEA-predicted fracture gap motion would predict callus formation in a clinical series of distal femur fractures following locked plating.

Methods: A 3-dimensional FEA model of a comminuted distal femur fracture treated with locked plating was developed to analyze fracture gap motion under single limb stance. The model allowed variation of plate material and bridge span to simulate constructs from 64 clinical cases that had been assessed for callus formation at 6, 12, and 24 weeks. Multivariate linear regression analysis assessed the effects of vertical motion and horizontal motion on callus formation. We then selected the "optimal construct" from the clinical case series based on the findings of the regression analysis. Student's *t* test was performed for statistical comparison of callus formation at 6, 12, and 24 weeks between this "optimal construct" and all others.

Results: Substituting titanium for stainless steel approximately doubled both horizontal and vertical motion, while increasing bridge span dramatically increased horizontal motion (shear) with a much lesser effect on vertical motion. Multivariate regression analysis demonstrated vertical motion promoted callus formation with a trend at 6 weeks ($P = 0.08$) and statistical significance at 12 and 24 weeks ($P < 0.05$). Shear was found to inhibit callus formation with a trend at 12 weeks ($P = 0.08$) and statistical significance at 24 weeks ($P < 0.05$). These results predicted that short titanium constructs (maximizing vertical relative to horizontal motion) would be associated with greater callus formation among constructs in the clinical case series. This was found to be true as short titanium constructs had greater callus at all time points ($P < 0.05$).

Discussion/Conclusion: FEA-predicted 3-dimensional gap motion was predictive of callus formation in a clinical case series of distal femur fractures. Predicted vertical motion was associated with increasing callus while predicted shear was associated with decreasing callus. Titanium constructs produced greater vertical motion, promoting callus formation. Increasing bridge span dramatically increased shear at the fracture, inhibiting callus formation. Future implant design and surgical fixation strategies should consider optimizing 3-dimensional fracture gap motion rather than optimizing surrogate measures such as axial stiffness.

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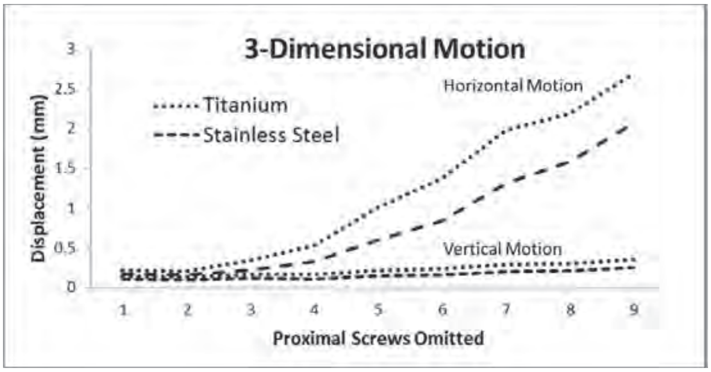

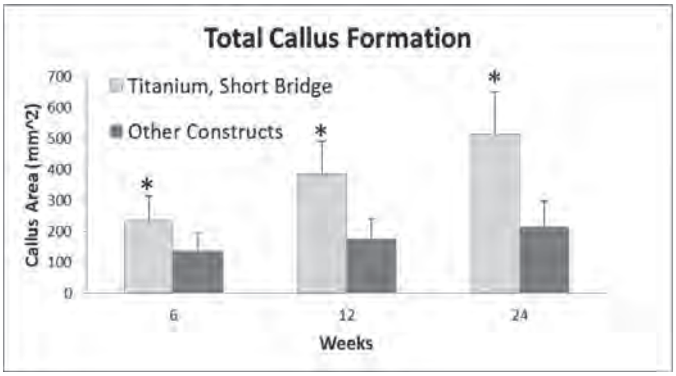

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The Minimal Screw Length for Tricortical Syndesmosis Fixation in Ankle Fracture: A Cadaveric Study

Derrick O. Cote, MD[1]; *Alexander C.M. Chong, MSAE, MSME*[1,2]; *Bradley R. Dart, MD*[1]; *Nils Hakansson, PhD*[3]; *Michael Ward*[3]; *Pie Pichetsurnthorn*[3]; *Paul H. Wooley, PhD*[1,2];
[1]*Department of Surgery, Section of Orthopaedics, University of Kansas School of Medicine-Wichita, Wichita, Kansas, USA;*
[2]*Orthopedic Research Institute, Wichita, Kansas, USA;*
[3]*Bioengineering Program, Wichita State University, Wichita, Kansas, USA*

Background/Purpose: Syndesmotic injuries of the ankle commonly occur via an external rotation force applied to the ankle joint. The effects of the screw length for single tricortical syndesmosis fixation of a syndesmotic injury can be assessed by evaluating the 3-dimensional kinematic behavior of the tibiofibular diastasis. Previous studies have explored the differences of 3 versus 4 cortices showing no difference between both fixation methods. To our knowledge no study has shown the kinematic behavior using a biomechanical study of single tricortical screw fixation with varied lengths. The specific aim of this study was to determine the minimal tricortical syndesmosis screw length for tibiofibular syndesmosis reduction fixation.

Methods: 15 fresh-frozen cadaveric lower extremities used for testing. A specially designed apparatus was used to stabilize the specimen and rotate the ankle joint in 25° of internal rotation and 35° of external rotation for 9 cycles in each direction. Three stages were tested: intact (Stage I), injury (Stage II), and fixation (Stage III). For Stage III, fixation was accomplished with a single 3.5-mm cortex metallic syndesmosis screw with 3 different predetermined screw lengths. Group I was fixed with threads less than 35% across the width of the metaphysis of the tibia after syndesmotic fixation 4 cm proximal to the plafond; Group II was fixed with the screw threads between 35% and 65% across the width of the metaphysis of the tibia after syndesmotic fixation; and Group III was with the screw threads juxtaposing the far cortex of the tibia after syndesmotic fixation (>65% across the width of the metaphysis of the tibia). Axial loading, torque, rotational angle, and 3-dimensional syndesmotic diastasis readings were recorded.

Results: Our torque results indicated that after the deltoid, anterior tibiofibular ligament, and interosseous ligaments were sectioned, the foot lost 74% and 61% torsional strength compared to the intact specimen for the foot externally rotated 35° and internally rotated 25°, respectively. However, there was no statistically significant difference detected in foot torsional strength between the 3 groups of screw fixation specimens and simulated injury specimens for either foot rotations. The torque of the three groups when externally rotated 50° was found not significantly different between each group (Group I: 9 ± 5 Nm; Group II: 8 ± 3 Nm; Group III: 13 ± 5 Nm). However, 2 fractures of the fibula were detected for Group I, 3 were detected for Group II, and 4 were detected for Group III.

Conclusion: This study supports the hypothesis that there is no significant difference in stability between different screw length constructs for tricortical syndesmosis screw fixation. This study shows that fixation of the distal tibiofibular sydesmosis with differing screw lengths did not provide a difference in torque applied to the syndesmosis. Fixation did not

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provide a difference in torque from sectioned ligaments to fixation in our study. Therefore, it is advised that patients should not bear weight in the period necessary for ligaments to heal.

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BSFF SYMPOSIUM 2: INFLAMMATION

Moderators: *Peter V. Giannoudis, MD*
Chelsea Bahney, PhD

9:55 am	**Prophylaxis in Trauma Patients: What is the Standard?** *H. Claude Sagi, MD*
10:00 am	**Inflammation and Healing: When is Too Much a Bad Thing?** *Chelsea Bahney, PhD*
10:10 am	**Inflammatory-Related Cytokines: What Role Do They Have in Healing?** *David J. Hak, MD, MBA*
10:20 am	**Can PRPs Modulate the Inflammatory Response During Healing?** *Peter V. Giannoudis, MD*
10:30 am	**Anti-Inflammatories: How and When Can They be Useful in Orthopaedic Trauma?** *David W. Sanders, MD*
10:40 am	**Systemic Trauma: Evidence-Based Recommendations for Timing of Fixation in 2013** *Hans-Christopher Pape, MD*
10:50 am	Discussion

NOTES

Δ OTA Grant

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Δ Age-Related Changes in Macrophage Polarization Affect Osteogenesis

*Fei Gao, MD, PhD; **Jesse A. Shantz, MD, MBA**; YanYiu Yu, PhD; Thedore Miclau, III, MD; Ralph S. Marcucio, PhD;*
San Francisco General Hospital, Orthopaedic Trauma Institute, San Francisco, California, USA

Purpose: Aging affects many cellular functions of macrophages, and macrophages exhibit various phenotypes depending on the inflammatory environment in which they are located. After injury macrophages exhibit a proinflammatory phenotype, termed M1, and then the macrophages polarize to an anti-inflammatory phenotype (M2). The M2 phenotype is associated with stimulation of healing. We hypothesized that the phenotype and function of macrophages changes with age, and these changes would affect osteogenesis. Therefore, we developed a macrophage/preosteoblast coculture system to assess the interreaction between these two cell types as a function of age.

Methods: Bone marrow monocytes were isolated from mice that were either 10 weeks old or 18 months old. Cells were differentiated into macrophages (bone marrow–derived macrophages [BMM]) in vitro. 10 ng/mL interferon gamma (IFN-γ) combined with 10 ng/mL lipopolysaccharide (LPS) were introduced to the media to activate BMM to a proinflammatory phenotype (M1) and 1 ng/mL interleukin (IL)-4 was used to drive macrophages toward an anti-inflammatory phenotype (M2). Proinflammatory cytokines and anti-inflammatory cytokines were tested by enzyme-linked immunosorbent assay (ELISA) from R&D Systems. M1 marker nitric oxide (NO) was assayed using the Griess reagent system and M2 marker levels (YM1 and FIZZ1) were quantified by quantitative polymerase chain reaction (qPCR). Macrophages of different phenotypes were then cocultured with preosteoblast cell lines (Cab2t3) in 3 configurations: (1) standard coculture, (2) macrophage-conditioned media and Cab2t3 cells, and (3) trans-well coculture. We used qPCR to quantify Runx-2, ALP, Col1a, osteocalcin, osteopontin, and osterix expression at different time points (D3, D7, D10, D14) during osteoblast differentiation. Alizarin red staining was used to quantify mineralization and alkaline phosphatase was quantified to assess osteogenesis.

Results: *BMM from aged mice secrete higher levels of proinflammatory cytokines*: IL-6 levels in 10 weeks BMM and M2 group were significantly lower than 18 months BMM and M2 group, while IL-10 does not appear to be different. *Polarization of macrophages from mice of different ages*: BMM from 10-week-old mice secrete lower levels of NO and upregulated gene expression of YM1 and FIZZ1 compared with BMM generated from 18-month-old mice. *Effect of different phenotype of macrophages on the bone cells differentiation:* In the 10-week group, osteocalcin, osteopontin, and osterix gene expression were reduced in both M1 and M2 group from 10-week-old mice. In the 18-month group, osteocalcin, osteopontin, and osteoterix in M1 group were not significantly different than controls, but M2 macrophages stimulated higher expression levels of these genes. *Effect of different phenotype of macrophages on the bone cells osteogenesis:* In standard coculture system, osteogenesis of Cab2T3 cells did not show any difference between different age groups. In condition media and trans-well coculture system, Cab2t3 cells have more osteogenic nodules in the M2 group than M1 group from 10-week mice. However, for BMM from 18-months mice, more nodules were detected in the M1 group than the M2 group.

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Conclusion: We demonstrate that macrophages from aged mice exhibit a more proinflammatory phenotype compared with macrophages from young adult animals. Our results suggest that osteogenesis may be impaired in inflammatory environments that do not resolve, while M2 macrophages are beneficial for osteogenesis. This is consistent with other conclusions that M2 cells are good for tissue repair and regeneration. These data support our hypothesis and suggest that regulating macrophage polarity may be important for bone repair in aged patients.

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T-Lymphocyte Immune Modulation in Fracture Healing: The Role of IL-17F in a Novel GSK3/β-Catenin Independent Pathway

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[1]Sunnybrook Health Sciences Center, Toronto, Ontario, Canada;
[2]Hospital for Sick Children, Toronto, Ontario, Canada

Purpose: Previous work established the importance of interleukin-17F (IL-17F) in T-lymphocyte mediated osteoblast maturation during the early inflammatory phase of fracture repair. We hypothesize that IL-17F regulation of osteogenesis occurs through known signaling pathways of bone healing, specifically Runt-related transcription factor 2/core-binding factor subunit alpha-1 (Runx2/cbfa1), a key transcription factor in osteoblast development and the Wnt/glycogen synthase kinase 3β (GSK3β)/β-catenin signaling pathway.

Methods: Preosteoblast mouse cell line MC3T3-E1 and primary bone marrow stromal cells (MSC) differentiated to osteoblasts from 12-week-old wild-type (C57BL/6) mice were cultured and treated with IL-17F. After 3 days incubation, RNA extraction with Trizol and quantitative RT-PCR (real-time polymerase chain reaction) was performed for mature bone formation markers (Collagen 1 [Col1]), osteocalcin, Runx2, and bone sialoprotein [BSP]). For analysis of protein expression, preosteoblast MC3T3-E1 mouse cell line was used and treated with IL-17F or Wnt3a and lysates was obtained after 4 days. Western blot analysis using anti-cbfa1, phospho-GSK3-(Ser9), and (Tyr216) antibodies was performed on cell lysates. Densitometry analysis was used to quantitate the protein expression levels relative to the expression of housekeeping gene, actin.

Results: Preosteoblast cell cultures (MC3T3-E1 and primary bone MSC) treated with IL-17F resulted in a significant increase in expression of markers for osteoblast maturation compared to untreated controls, namely Col1, osteocalcin, Runx2/cbfa1, and BSP ($P < 0.05$). Upregulation of Runx2/cbfa1 expression was confirmed on Western blot analysis showing increased Runx2/cbfa1 levels after IL-17F treatment compared to control with no treatment. In fact, this was similar to expression levels seen with Wnt3 treatment, a known upstream stimulator of Runx2/cbfa1 expression. Interestingly, IL-17F upregulation of the osteoblast transcription factor Runx2/cbfa1 appears independent of the known Wnt-β-catenin pathway. The phosphorylation of the Ser9 site on GSK3β suppresses β-catenin degradation and allows its nuclear translocation to activate downstream targets such as Runx2/cbfa1, to promote bone formation. Western blot analysis showed that IL-17F treatment leads to almost no Ser9 phosphorylation and high levels of Tyr216 phosphorylation, which is consistent with increased GSK3β activity and thus, β-catenin degradation. Yet, despite this, treatment with IL-17F leads to similar increased expression of Runx2/cbfa1 downstream, lending evidence for a GSK3/β-catenin independent manner of IL-17F stimulated osteogenesis.

Conclusion: IL-17F, a pro-inflammatory cytokine secreted by T-lymphocytes, stimulates osteoblast maturation in fracture healing through a novel GSK3-independent pathway.

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Δ Lipopolysaccharide-Induced Systemic Inflammation Affects Bone Healing in a Murine Tibia Fracture Model

Jesse A. Shantz, MD, MBA*; Fei Gao, MD, PhD; Yan-Yiu Yu, PhD; Theodore Miclau III, MD; Ralph Marcucio, PhD;*
Department of Orthopaedic Surgery, University of California, San Francisco, San Francisco, California, USA

Background/Purpose: The early stages of fracture repair require close coordination between the immune system and skeletal system. Conditions such as diabetes, rheumatoid arthritis, smoking, obesity, and aging adversely affect bone healing. Common to all these conditions is a sustained inflammation. It has been shown that lipopolysaccharide-induced systemic inflammation results in fracture callus of inferior mechanical characteristics in a rat femur fracture model. The aim of this study was to compare fracture healing in a murine tibia fracture model in the setting of lipopolysaccharide (LPS)-induced systemic inflammation to that of control animals.

Methods: Sustained inflammation was created by the injection of lipopolysaccharide (3 μg/animal/day, *E. coli* O55:B5 LPS) intraperitoneally. Control animals received equivalent volume of phosphate-buffered saline vehicle. Concurrently, diaphyseal tibial fractures were created and stabilized with intramedullary pins. Plasma and tibiae were collected on day 1 (D1), D3, D7, D10, D14, and D21 (N = 3 per time course per group). Plasma was isolated from whole blood by centrifugation at 2000*g* for 20 minutes. All plasma samples were immediately stored at –20°C after isolation. Interleukin (IL)-6 levels were detected by ELISA (enzyme-linked immunosorbent assay). Prepared ELISA plates were read as suggested by the manufacturer. Concentrations were expressed in pg/mL. All samples were run in duplicate.

Harvested limbs were fixed in 4% paraformaldehyde and decalcified in EDTA (ethylenediaminetetraacetic acid) for 14 days, after which they were paraffin embedded and sectioned at 5 μm. Every tenth section was stained using a trichrome stain. Adjacent sections were stained using the method of Hall and Bryant. Sections were then examined and tissue types were quantified by stereology. Calculated volumes were expressed in mm^3. Mean volumes were compared using the Student *t* test with a significance level of $P < 0.05$ employed.

Results: *LPS Injection:* During the 7-day injection period no behavioral differences were noted between treated and control animals. No symptoms of systemic illness were noted in either group. One mortality occurred in the control group. *Plasma IL-6 Levels:* For the LPS group, the IL-6 level rose shapely to concentration of 209.9 pg/mL 24 hours after fracture whereas the maximum IL-6 level reached by controls was 23.5 pg.mL (Figure 1). IL-6 levels decreased in both groups to near-basal levels by postfracture day 3 in controls and day 7 in the LPS-treated animals. *Fracture Healing Under Inflammatory Conditions:* At day 7 the treatment group trended towards a smaller mean callus volume (mean difference $15.5mm^3$; $P = 0.21$) (Figure 2). By day 10 and 14 there was no difference in callus size between groups. The difference in callus size was primarily related to an increased volume of cartilage and undifferentiated tissue in control animals (Figure 2). Hall-Bryant quadruple stain confirmed the larger callus in control animals (mean difference 17.4; $P < 0.076$) (Figure 3). The size dif-

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ference noted was present in all tissue types, suggesting an overall smaller callus, rather than a difference in one cell type.

Conclusion: The injection of LPS into the peritoneal cavity of mice concurrent with tibia fracture results in delayed fracture healing based on the results of this study. The injection of LPS is also associated with increased systemic IL-6 production in treatment animals; however, no symptoms of systemic inflammation were noted when compared with control animals. Analysis of fracture site tissue distribution suggests that systemic inflammation causes a smaller fracture callus at day 7. Further work is required to define the individual inflammatory and skeletal cell populations at the fracture site and to determine if the observed histomorphometric differences translate to mechanical inferiority of the callus of treatment animals.

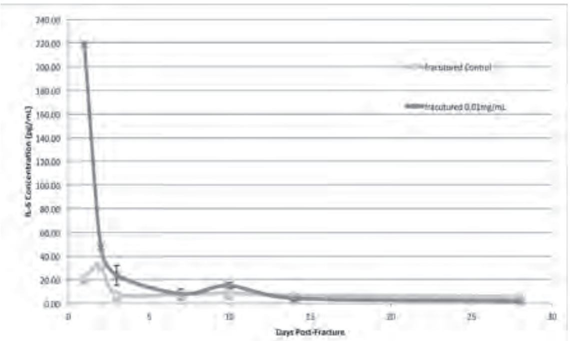

Figure 1: IL-6 plasma concentration after fracture and injection of LPS or control vehicle. Concentrations measured by ELISA.

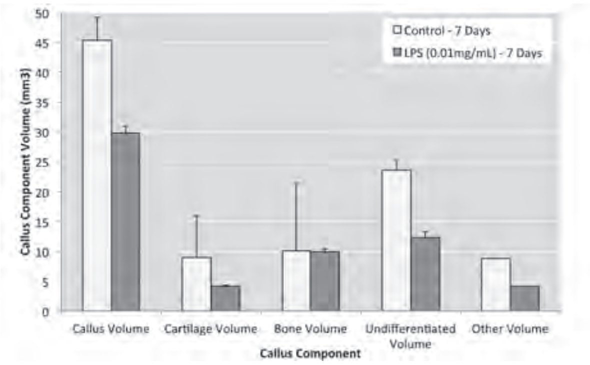

Figure 2: The effect of LPS-induced inflammation on callus size at postfracture day 7 as determined by trichrome staining.

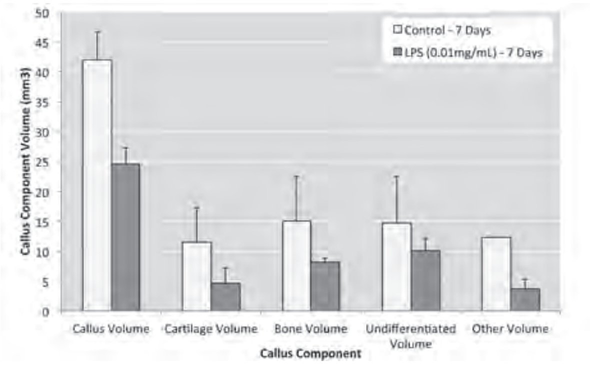

Figure 3: The effect of LPS-induced inflammation on callus size at postfracture day 7 as determined by Hall-Bryant quadruple staining.

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BSFF SYMPOSIUM 3: BONE GRAFTING

Moderators: *Joseph Borrelli, Jr., MD*
Kenneth A. Egol, MD

12:45 pm **Efficacy of Autografts: Do Harvest Sites Matter?**
Aaron Nauth, MD

12:55 pm **Grafting in the Setting of Infection: Strategies**
Hans-Christoph Pape, MD

1:05 pm **Bone Graft Extenders: Which Ones Work?**
J. Tracy Watson, MD

1:15 pm **Bone Graft Timing: What is Most Optimal?**
Mark A. Lee, MD

1:25 pm **Bone Graft Substitutes: Is Anything as Effective as Autograft?**
Kenneth A. Egol, MD

1:35 pm Discussion

NOTES

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Δ The Influence of Construct Stiffness on Bone Regeneration in a Rodent Defect Model

Joel C. Williams, MD; *Matthew J. Anderson, MS; Blaine A. Christiansen, PhD;*
A. Hari Reddi, PhD; Mark A. Lee, MD;
University of California Davis, Sacramento, California, USA

Background/Purpose: Critical-sized bone defects (CSDs) have a multifactorial etiology including high-energy trauma, infection, revision surgery, and tumor resection. CSDs are a major clinical dilemma, as reliable, evidenced-based solutions do not exist. The purpose of this study was to investigate the relationship between construct stiffness and bone morphogenetic protein (BMP) response in a reproducible rodent CSD model. We used 2 specific aims to test our hypothesis. In *Aim 1*, we performed an ex vivo validation of custom modifications to a locked internal fixation device to create 3 angular stable constructs of varying stiffnesses. In *Aim 2*, we used an in vivo rodent model with BMP-7 to compare the effects of varied stiffness on bone regeneration.

Methods: In *Aim 1*, axial and torsional stiffness of a commercially available rat internal fixation system that consisted of a radiolucent polyetheretherketone (PEEK) plate and 6 angular stable bicortical titanium screws were quantified. Three constructs with varied stiffness were created via plate modification or modification of plate configuration (Figure 1). In *Aim 2*, 35 skeletally mature, male Fischer 344 rats underwent a unilateral operation to create a 6-mm CSD and were then randomized to 1 of the 3 stiffness groups. All defects were treated with 100 μg/25 μL BMP-7 on absorbable collagen sponge (ACS). In vivo radiographs were obtained at 2-week intervals until the end of treatment and graded 0 (no bone formation), 1 (bone formation, possible union), or 2 (union) by 2 blinded investigators. All animals were sacrificed at 8 weeks to examine bone formation using radiographs, micro-CT and biomechanical testing.

Results: *Aim 1:* Axial stiffnesses of the flexible, intermediate, and rigid constructs were 7.8 N/mm, 17.9 N/mm, and 66.4 N/mm, respectively. Torsional stiffnesses of the flexible, intermediate, and rigid constructs were 2.3 Nmm/deg, 5.9 Nmm/deg, and 13.5 Nmm/deg, respectively. *Aim 2:* At the end of the experiment (8 weeks), 73% of the flexible stiffness group, 100% of the intermediate stiffness group, and 63% of the rigid group had radiographically united. he intermediate group formed significantly more bone volume (BV) and callus volume (CV) than the rigid group, but it was not significantly higher than the flexible group. There were no significant differences when apparent bone mineral density, a measure of mineralization of newly formed bone, or BV/CV were analyzed. Torsional stiffness and torque to failure of the intermediate group were over threefold higher than the rigid group, but not significantly greater than the flexible group.

Conclusion: Using modifications to a commercially available rodent internal fixation device, we were able to create 3 different mechanical stiffness environments in a rodent CSD model. The response of BMP-7 mediated bone regeneration, appeared directly related to construct stiffness. The intermediate stiffness group demonstrated the highest bone and callus volume with the highest load to failure. This suggests that when treating a CSD, mechanical stability is just as important as addressing the biologic factors.

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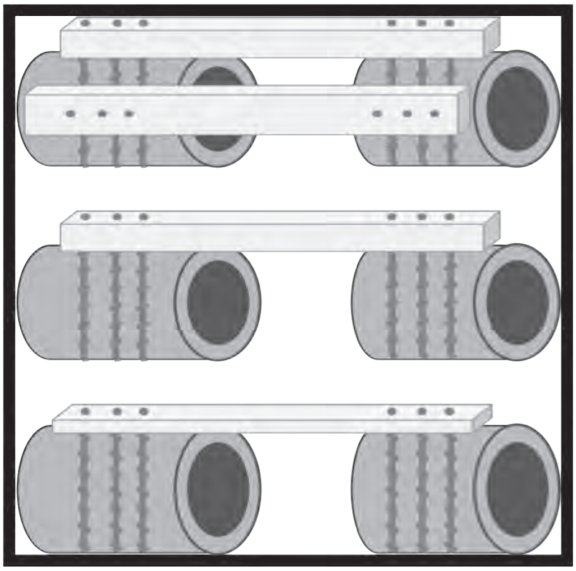

Figure 1: Schematic of rigid (top), intermediate (middle), and flexible (bottom) constructs

See pages 91 - 132 for financial disclosure information.

Δ A Novel Rodent Critical-Sized Defect Model and BMP-7 Dose Response Study

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Background/Purpose: Bone regeneration for critical-sized bone defects (CSDs) following trauma, tumor, or infection treatment represent a major clinical challenge, as reliable, evidenced-based solutions are limited. Multiple small animal CSD models exist, but most are limited by the inability to precisely control the mechanical environment and reproducibly recreate the bone defect. The first aim of this investigation was to develop and validate a novel, easily translatable, and reproducible rodent CSD model. The second aim was to determine the optimal dose required to consistently heal the CSD.

Methods: 6-mm diaphyseal CSDs were created in femora of skeletally mature male Fischer 344 rats and stabilized with a radiolucent polyetheretherketone (PEEK) plate and 6 angular stable bicortical titanium screws. Rats were randomly assigned to 5 treatment groups based upon the dose of bone morphogenetic protein (BMP)-7 on absorbable collagen sponge (ACS) placed within the defect: 100, 75, 50, 25 μg/25 μL, or ACS alone (control). Surveillance radiographs were obtained at 2-week intervals until the end of treatment and scored 0 (no bone formation), 1 (possible union), or 2 (union) by 2 blinded investigators. All animals were sacrificed at 8 weeks to examine bone formation using radiographs and micro-CT and to perform biomechanical testing.

Results: All of the 100-μg group demonstrated 100% radiographic union by week 4 and all 75 and 50-μg group rats united by week 6. None of the animals in the 25-μg group or control group united at the time of sacrifice. Bone volume (BV) (Figure 1), bone mineral density, the ratio of bone volume to total volume, stiffness, and ultimate load to failure was maximal in the 50-μg group. Total callus volume (CV) (Figure 2) progressively increased with increasing BMP dose. The ratio of mineralized bone tissue relative to total callus volume (BV/CV) decreased as BMP-7 dose increased. The 100-μg group was less than half of 25-μg and control groups. Apparent bone mineral density (ABMD) (Figure 3), a measure of mineralization of newly formed bone, showed a relationship similar to BV/CV, which decreased with increasing BMP dose. None of the control or 25-μg femurs bridged the defect, therefore they were not used for biomechanical evaluation. Torsional stiffness of the femurs in the 50 and 75-μg groups were similar to the intact contralateral control group. The torsional stiffness for the 100-μg group was 67% and 60% that of intact contralaterals and the 50-μg group, respectively. The ultimate load to failure of the femurs in the 50 and 75-μg groups were similar to the intact contralateral control group. The ultimate load to failure for the 100-μg group was 82% and 71% that of intact contralaterals and the 50-μg group, respectively.

Conclusion: BMP-7 delivered with an ACS in our mechanically stable rodent CSD model results in consistent, high-quality bone regenerate. The 50 μg/25 μL dose appeared to optimize the BMP-7 response. This highly reproducible system will be valuable in ongoing studies of biologic augmentation techniques as well as providing the ability to study the influence of mechanical fixation conditions on bone repair strategies.

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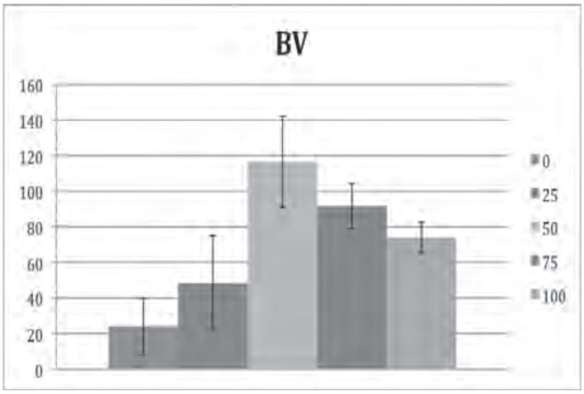

Figure 1

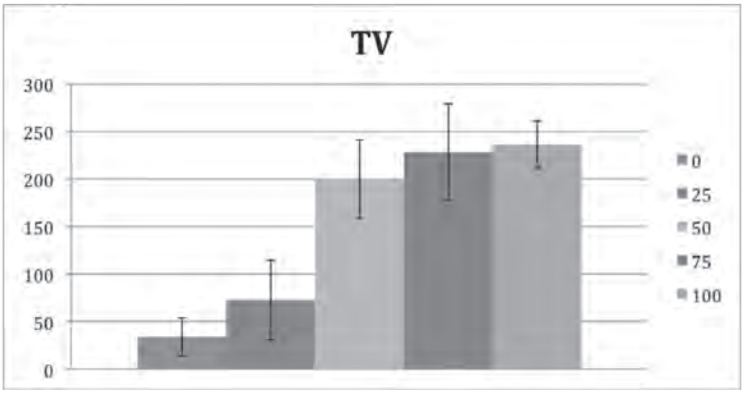

Figure 2. TV = total callus volume.

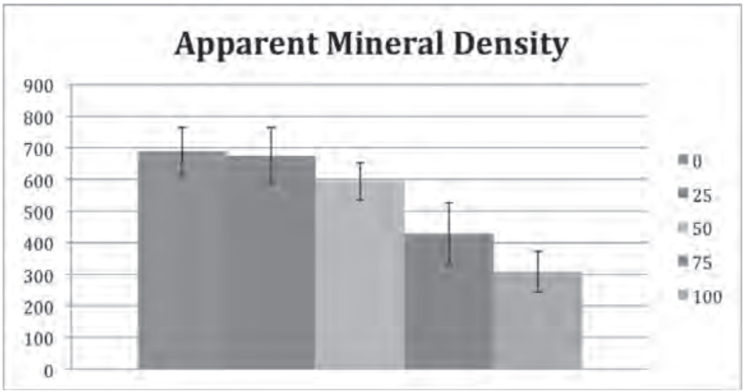

Figure 3

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Spacer Composition Influences Properties of the Masquelet Membrane in Animals and the Observed Gene Expression Patterns of Inducible Membranes in Humans

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Background/Purpose: It has been previously established that the Masquelet membrane, which forms around antibiotic cement spacers used in long bone segmental defects, stimulates bone healing. However, it is unknown whether the properties of the Masquelet membrane may be manipulated by controllable factors, such as the spacer material. Also, the characteristics of the Masquelet membrane, as well as membranes that form on other orthopaedic implants, have not been characterized in humans. We studied the effect of the spacer material on the ability of the Masquelet membrane to promote osteogenesis in an animal model and the gene expression patterns of membranes obtained from humans.

Methods: Bilateral critical-sized osseous defects were created in the ulnae of 12 rabbits. Spacers composed of stainless steel (SS) or polymethymethacrylate (PMMA) were inserted into the intercalary defects, and the animals were allowed to heal for 4 or 8 weeks. At sacrifice, we obtained samples of the induced membrane that formed around the spacers for cell culture evaluation. We also obtained human membrane samples (n = 8) at the time of planned implant removal surgery and conducted gene expression analyses.

Results: In our animal model, membranes obtained after 8 weeks of healing were able to influence the osteogenic properties of the osteoblast (OB) precursors contained within the autologous bone marrow. Specifically, the membrane from around the PMMA spacer promoted significantly greater alkaline phosphatase activity in culture than bone marrow cells alone. This suggests that the PMMA spacer was able to increase the numbers of early OBs in culture. At the same time, the membrane from around the SS spacer significantly increased mineral deposition in culture compared to bone marrow cells alone, indicating increased numbers of mature OBs in culture. With respect to our human induced membrane samples, we observed elevated expression of OB-related genes in all of the samples.

Conclusion: While membranes from both spacers were able to increase OB activity in culture, the SS spacer increased numbers of mature OBs, suggesting that it may promote formation of mature bone faster. This provides empirical evidence that spacers could be designed to specifically enhance the osteogenic properties of the Masquelet membrane. Furthermore, inducible membranes that form around orthopaedic implants and spacers in humans have a pattern of gene expression, suggesting that they contain active cells of the OB lineage. Continued study of these tissues may lead to further insight into how they augment bone healing and contribute to the design of improved orthopaedic implants in the future.

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PAPER ABSTRACTS

PAPER ABSTRACTS

The Masquelet Technique Induces the Formation of a Mesenchymal Stem Cell–Rich Periosteum-Like Membrane

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Background/Purpose: The Masquelet or induced-membrane technique was first described by A. C. Masquelet in 1986 for the reconstruction of large diaphyseal bone defects. Given the excellent skeletal repair noted with this 2-stage technique, we hypothesized that mesenchymal stem cells (MSCs) were likely to be key players given their high proliferative potentials and osteogenic capabilities. This study represents the first characterization in humans of the induced membrane formed as a result of the Masquelet technique.

Methods: Induced membranes harvested from 8 patients undergoing treatment for reconstruction of long bone defects were compared to neighboring healthy periosteum. A portion of each sample was processed for histology and immunohistochemistry; a second portion was enzymatically digested in preparation for flow cytometry and culture expansion. Basic structural composition was assessed using histological stains, the localization of cytokines (bone morphogenetic protein [BMP]-2, vascular endothelial growth factor [VEGF], and stromal derived factor [SDF]-1) and cell lineage markers (CD31, CD271, CD146) were studied by immunohistochemisty. Flow cytometry was used to measure the cellularity and the cell composition of the digested material including: bone marrow (BM) MSCs ($CD45^{low/-}CD271^{+}$ or $CD45^{low/-}CD146^{+}$) and endothelial cells ($CD45^{-}CD31^{+}$). The number of MSCs per gram of tissue was determined using a colony-forming unit fibroblast (CFU-F) assay. In expanded cultures, a 96-gene array card was used to assess their transcriptional profile. Following in vitro differentiation, alkaline phophatase, alizarin red, and calcium assays were employed to measure their osteogenic potential.

Results: Periosteum and induced membrane had similar structural characteristics, cytokine, and cell lineage localization. Membrane was more cellular than periosteum (~7×10^6 cells/g compared to 3.5×10^6 cells/g, $P = 0.028$). A high proportion of cells in the induced membrane had the $CD45^{low/-}CD271^{+}$ phenotype (~29%), compared to a relatively lower proportion in matched periosteum (median 5%, $P = 0.043$). The molecular profile of membrane- and periosteum-derived MSC cultures was similar, with exception of the transcript for *SDF-1* (*CXCL12*), which was twofold more abundant in the membrane ($P = 0.043$). Membrane and periosteum had a similar proportion of endothelial cells, as well as comparable numbers of CFU-F colonies per gram (~3000-6000/g); expanded MSCs from both sources were highly osteogenic.

Conclusion: These results indicate that not only does the induced membrane provide the vascular network and characteristics consistent with healthy periosteum but also possesses a rich source of MSCs able to directly participate in bone regeneration. Due to the highly chemoattractive and osteogenic nature of the induced membrane, our findings support the view that the induced membrane plays an active role in bone regeneration.

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Opiates Impair Healing in Rat Femur Fracture Model

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Background/Purpose: There is very limited literature looking at the effects of opioids on fracture healing. There is evidence that opioids reduce serum testosterone in humans and animals. Testosterone has shown to have beneficial effects on fracture healing. However, opioid-induced androgen deficiency (OPIAD) has never been evaluated in the acute fracture setting. This study is designed to determine if opioid medication(1) reduces testosterone; (2) impairs bone healing in an animal model; and (3) whether this may be reversed with supplemental exogenous testosterone.

Methods: An established femur fracture model was used in 75 Sprague-Dawley rats. All animals underwent an identical operative procedure. The midshaft fracture was stabilized with a 2-mm gap using a 4-hole 1.5-mm plate and 4 bicortical screws. Postoperatively, subjects were randomized into three treatment groups: control (C), morphine (M), and morphine plus testosterone (MT). Group M (morphine) subjects were given subcutaneous injections of morphine (5 mg/kg) every 8 hours. Group MT subjects were given subcutaneous injections of morphine (5 mg/kg) every 8 hours plus 50 mg/kg of testosterone enanthate given subcutaneously every 2 weeks. Control animals received equal volumes of saline subcutaneous injections every 8 hours to control for any stress or trauma-associated alterations in serum testosterone levels. Testosterone levels were recorded preoperatively, and at 48 hours, 4 weeks, and 8 weeks postoperatively. Equal numbers of subjects from each group were sacrificed at 4 weeks and 8 weeks postoperatively. Three-point bend testing was performed and evaluated as a ratio of osteotomy callus strength to the nonoperative contralateral femur strength to account for variables among the subjects. Histology and micro-CT scans were utilized to evaluate postoperative callus.

Results: Serum testosterone levels in group M subjects showed a significant decrease (P <0.001) and group MT showed a significant increase (P <0.001) compared to controls at all time points measured. Callus strength analysis used a ratio of operative femur strength to nonoperative femur strength. No significant differences were seen at 4 weeks in callus biomechanical testing, but by 8 weeks, group M demonstrated a statistically significant drop in callus strength compared to controls (48.5% vs 30.2%, P <0.05). Group MT showed that this effect is not reversed by testosterone supplementation (48.5% vs 32.8%, P = 0.127). Radiographic and histologic analysis showed delayed callus maturation and lack of remodeling in the M and MT groups compared to controls at 8 weeks.

Conclusion: Opioids appear to inhibit fracture callus strength by inhibiting callus maturation and remodeling as seen both histologically and radiographically in this rat femur fracture model. Testosterone suppression occurs almost immediately (within 2 days postoperatively) and is continually suppressed throughout the 8-week duration of study. This study does not establish causality between testosterone suppression and inhibited bone healing, particularly as testosterone supplementation did not reverse the effects on callus strength in the subjects receiving opiates.

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Systemic Inhibition of Notch Signaling Alters Multiple Phases of Fracture Healing

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Purpose: Notch signaling components are upregulated during bone repair and are expressed in mesenchymal cells. However, the direct mechanistic role of the Notch signaling pathway during fracture repair is unknown. Therefore, the objective of this study was to determine the importance of Notch signaling in regulating fracture healing.

Methods: We used an inducible promoter (Mx1-Cre) crossed with a transgenic mouse (dominant negative MAML, dnMAML) to impair Notch signaling in all cells during repair. The dnMAML transgene is a truncated nonfunctioning version of MAML, which is required to support transcription of Notch target genes. Activation of dnMAML inhibits MAML activity and thus the Notch signaling pathway. dnMAML is preceded by a floxed transcriptional stop sequence, which prevents its expression in the absence of Cre activity. Skeletally mature 3-month-old dnMAML (dnMAML$^{f/-}$ × Mx1-Cre+) and wild-type (dnMAML$^{f/-}$ × Mx1-Cre-) mice were injected with 500 μg of polyI:C (polyinosinic:polycytidylic acid) to activate the Mx1 promoter, resulting in Cre expression and deletion of the floxed stop sequence preceding dnMAML, allowing for systemic dnMAML activation. Wild-type mice, which are negative for Cre, will therefore not express dnMAML. Following polyI:C injections, mice underwent bilateral closed, transverse, tibial diaphyseal fractures with intramedullary pin fixation. Fracture calluses were harvested at 5, 10, and 20 days postfracture (dpf) for gene expression analysis (n = 6-9) and 10 and 20 dpf for micro-CT (n = 7-13) and histologic analysis (n = 4-7).

Results: dnMAML expression decreased cartilage formation within the callus at 10 dpf (Figure, left) and increased the proportion of bone formation within the callus at 20 dpf (Figure, center) due to a decrease in callus volume with no change in bone mass. dnMAML also decreased osteoclast density at 20 dpf, corresponding with an increase in trabecular thickness, suggesting that impaired remodeling is primarily responsible for the bone phenotype. Interestingly, dnMAML expression prolonged expression of inflammatory cytokines (Figure, right) and neutrophil infiltration.

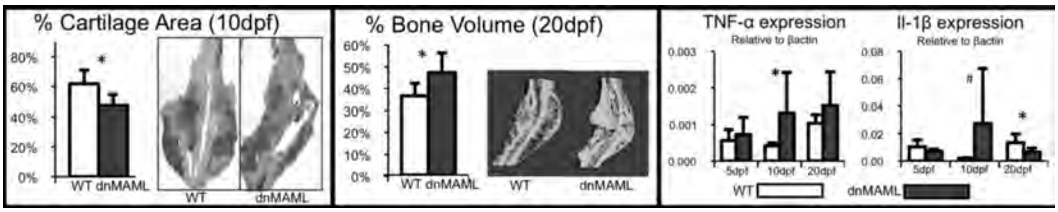

Figure: Cartilage (left, Safranin O histology) and bone formation (center, micro-CT), and inflammatory cytokine expression (right, gene expression) in dnMAML (gray) and WT (white) fractures. TNF-α = tumor necrosis factor alpha; IL-1β = interleukin-1 beta.

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Conclusion: Canonical Notch signaling is required for the proper temporal progression of healing, where systemic Notch inhibition prolongs inflammation, inhibits cartilage formation, and these in turn secondarily negatively alter bone maturation and remodeling.

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Unexpected Dispensable Role of MMP-9 in a Stabilized Femur Fracture Model

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Jonathan G. Schoenecker, MD, PhD;
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Background/Purpose: Previous research has identified matrix metalloproteinase-9 (MMP-9) as a key regulator of fracture healing. However, these studies were conducted in a closed, nonstabilized murine tibia fracture model. To determine if MMP-9 remained indispensable in promoting fracture angiogenesis in a more clinically relevant model, we used a murine stabilized transverse femoral fracture and compared key aspects of fracture healing, with an emphasis on vascularity, in mice with and without MMP-9. It was our hypothesis that MMP-9 would also prove to be essential for fracture healing in a stabilized femur fracture model.

Methods: We used a validated open femur fracture model on wild-type (WT) and MMP-9–deficient (MMP-9 KO) mice. Fracture healing was followed radiographically at 7, 10, 14, and 21 days postfracture (dpf). Mice were sacrificed at 7, 10, 14, and 21 dpf and were injected with radiopaque Microfil. Three-dimensional vascular reconstruction was achieved by using micro-CT; these images were merged with x-ray images to further depict vascularity progression. Using histology, we then measured cartilage (CA) and total callus area (TA) with which a ratio was produced, CA/TA (mm^2). The Student t test was used for evaluation of statistical significance between groups.

Results: Both WT (n = 17) and MMP-9 KO (n = 21) mice displayed similar fracture healing radiographically (Figure 1). At each end point, there were no statistically significant differences of CA/TA ratio in WT and MMP-9 KO mice by examining with safranin-O staining (Figure 2). Vascularity in the calluses of MMP-9 KO mice seemed similar to that of WT mice (Figure 3).

Conclusion: Despite previous reports, we found that a loss of MMP-9 resulted in no significant differences in the development of soft-tissue callus or vascular invasion and subsequent development and remodeling of hard-tissue callus in a stabilized femur fracture model. We hypothesize that our findings differ from the previously reported indispensable role of MMP-9 through two potential mechanisms: (1) stabilization of the fracture and 2) differences in the vascularity of the femur as opposed to the tibia, suggesting that MMP-9 is essential only in a fracture with a relatively reduced initial vascular supply. Future studies will be required to test these hypotheses and ultimately determine the role of MMP-9 in fracture healing. Nevertheless, these results highlight the potential differing results of various employed fracture models.

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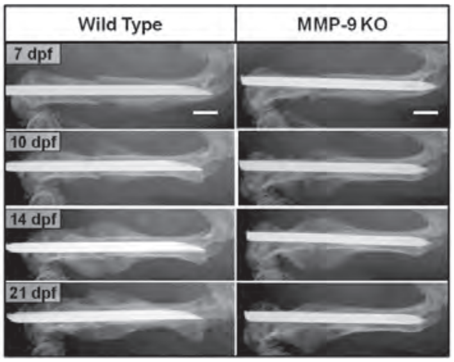

Figure 1

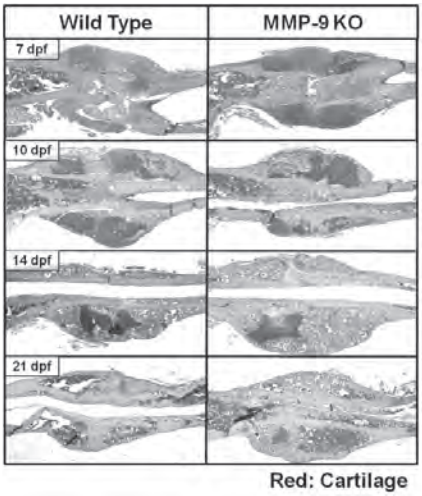

Figure 2

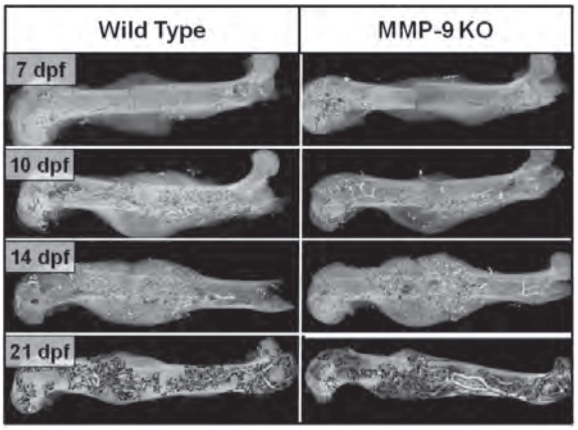

Figure 3

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Δ The Nonessential and Potentially Pathogenic Role of a Fibrin Clot in Fracture Healing

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Background/Purpose: A fibrin clot is inevitably the principal constituent of the initial matrix interposing two ends of fractured bone. It has been assumed that this fibrin clot is beneficial for fracture healing as, in addition to providing hemostasis, the clot is thought to represent the initial template of fracture healing. Hence, many principles of fracture care and pharmaceuticals have been developed to enhance a fibrin matrix in the fracture bed. Despite the assumed essential role of a fibrin matrix in fracture healing, its essential function has not been validated. Although there are likely beneficial functions of fibrin in fracture healing, recent evidence in other biological systems have implicated the accumulation of fibrin as a pathogenic factor in chronic diseases. For example, fibrin is thought to contribute to the loss of function of organs in chronic diseases such as Alzheimer's, multiple sclerosis, and muscular dystrophy. It is proposed that accumulated fibrin represents a physical barrier to the proper function of that tissue. The role of fibrin accumulation in impaired fracture healing has not been investigated. As fibrin is inevitably the initial matrix of fracture healing we hypothesized that fibrin is an essential component of fracture healing and that fibrin accumulation is associated with impaired fracture healing.

Methods: A midshaft femur fracture was created and stabilized by retrograde needle fixation on wild-type (WT), fibrinogen-deficient ($Fbg^{-/-}$), plasminogen-deficient ($Plg^{-/-}$) (which cannot remove fibrin), and $Plg^{-/-}$ (that have had fibrin[ogen]) knock-down mice. Fracture healing was analyzed by x-ray, micro-CT, angiography, and histology at 2 and 6 weeks postfracture (wpf). Fibrinogen levels in blood were measured by fibrinogen enzyme-linked immunosorbent assay (ELISA). Comparisons among the groups were performed using one-way analysis of variance (ANOVA).

Results: Mice lacking fibrinogen showed no differences in the timing, growth and remodeling of the hard callus compared with WT mice (Figure 1, *left 2 lanes*). $Plg^{-/-}$ mice developed heterotopic ossification and failed to reach union. Angiograms demonstrated that $Plg^{-/-}$ mice had deficient vascularity in the callus compared to WT and $Fbg^{-/-}$ mice (Figure 1, *bottom*). Consistent with these findings, there remained abundant avascular cartilage in $Plg^{-/-}$ mice. Fibrin immunohistochemical staining revealed abundant fibrin interposed between the avascular cartilage and vascularized bone where CD31-positive endothelial cells migrate into chondrocyte. Further, removing fibrinogen from $Plg^{-/-}$ mice partially rescued fracture healing and revascularization of the fracture callus.

Conclusion: As opposed to what has been accepted, fibrin is not essential for fracture healing. In addition, we established that accumulation of fibrin may result in heterotopic ossification and nonunion by impairment of angiogenesis at the fracture. Considering that many conditions that may result in pathologic fracture healing, such as diabetes, smoking, and aging, all have impaired fibrinolysis resulting in fibrin accumulation; these results may

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provide valuable insight into novel means of improving fracture healing in these populations by targeting fibrin degradation.

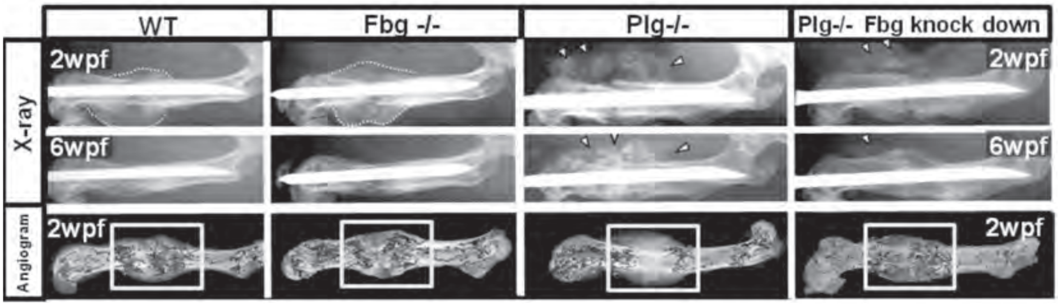

Figure 1: Radiographs at 2 and 6 wpf and revascularization in fractured femur.

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Δ Single Nucleotide Polymorphisms in Osteogenic Genes in Atrophic Delayed Fracture Healing: A Preliminary Investigation

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Background/Purpose: We examined the hypothesis that patients who exhibit delayed or impaired fracture healing may have one or more single nucleotide polymorphisms (SNPs) within a series of bone-related genes. These SNPs may affect fracture healing directly, or may interact with other epigenetic host or environmental factors to result in delayed fracture union. Identification of patients with a genetic basis for impaired fracture healing at the time of injury may justify more aggressive fracture treatment and possible mitigation of the morbidity associated with impaired healing. In addition, the identification of SNPs or SNP combinations highly correlated with defective fracture healing may lead to greater understanding of fracture healing at a genetic level.

Methods: We performed a population-based, case-controlled study of delayed fracture healing with a retrospective nested cohort. 62 adult long bone (femur, tibia, humerus, ulna) fracture patients (ages 18-79 years) were identified from a surgical database. 33 patients had an atrophic nonunion (delayed healing), and 29 displayed normal fracture healing. An atrophic nonunion was defined as a fracture with minimal callus formation 6 months after injury and requiring additional surgery to obtain union. In every case, the secondary surgery required the use of autogenous bone graft, or other inductive agent to augment the defective biology. Patients with grade III open fractures or positive bone cultures at the time of their nonunion surgery were excluded from the study. A normal healer was defined as a patient who displayed a healed fracture, as determined radiographically and clinically, at 6 months without secondary intervention. The senior author (J.S.R.), an experienced fracture surgeon, made the final determination regarding patient inclusion. These patients underwent buccal mucosal cell harvesting. SNP genotyping was performed using Illumina Golden-Gate bead array technology

Results: 144 SNPs within 30 genes associated with fracture healing were investigated (HapMAP). SNP genotyping quality control involved retaining only the genotypes with a GenCall score larger than 0.25 and retaining the SNPs having a GenTrain score larger than 0.25. Three SNPs (rs3758853, rs1143641, rs2075554) did not segregate in the population and were therefore excluded from the analysis. Finally, SNPs were tested for Hardy-Weinberg disequilibrium and are noted if the Hardy-Weinberg P value is smaller than the Bonferroni corrected level of 05/141 = 0.000355; none of the statistically significant SNPs were found to be in Hardy-Weinberg disequilibrium. There was no statistical difference in age, gender, or smoking history or anatomic location of fracture. Under a stringent Bonferroni adjustment for multiple comparisons (P <0.00037), none of the tested SNPs were significantly associated with defective fracture healing. However, using an additive genetic model, the following SNPs had significance at the 0.05 threshold level and may warrant further investigation. Odds ratio (OR) >1 indicates that the presence of the allele predisposed patients to nonunion, whereas OR <1 indicates that the presence of the allele protected patients from nonunion.

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SNP	Gene	*P* Value	Odds Ratio	Risk of Nonunion
rs2853550	IL1-β	0.0344	5.9	Increase
rs2297514	iNOS-2	0.0145	3.98	Increase
rs2248814	iNOS-2	0.0379	2.27	Increase
rs3819098	MMP-13	0.0262	0.257	Decrease
rs270393	BMP-6	0.0152	0.297	Decrease

IL = interleukin; iNOS = inducible nitric oxide synthase; MMP = matrix metalloproteinase; BMP = bone morphogenetic protein.

Conclusions: This study provides preliminary data that the techniques of SNP genotyping applied to the problem of defective fracture healing has merit and is worthy of further investigation. As the cost of performing these types of studies decreases, a genome-wide analysis on a large multicenter patient population will eventually become feasible. This may yield novel SNP/nonunion associations outside of those genes that are currently understood to be involved with fracture healing. Information from these studies may also direct further basic science investigations into the precise mechanisms of osseous healing and osseous integration of implants.

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Systemic Proteomic Profiles Associated With Healing and Nonunion of Midshaft Femur Fractures

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Background/Purpose: Approximately 5% to 10% of long bone fractures lead to a nonunion, requiring the patient to undergo additional procedures and treatment. There are no reliable measures to predict a nonunion; it can only be diagnosed radiographically after 3 to 6 months. A potential prospective method to identify patients predisposed to fracture nonunion is the use of biomarkers circulating in the serum. This method could enhance postoperative monitoring of healing progress and facilitate early detection of a nonunion, allowing for treatment to be properly adjusted. This study was designed to examine temporal shifts in systemic proteomic expression during fracture healing in a rat model, measurable by proteome-wide characterization techniques.

Methods: In 48 female rats, a diamond saw blade was used to create a midshaft femoral osteotomy. A nonunion was induced in 24 of these rats by cauterizing the periosteum circumferentially 2 mm proximal and distal to the osteotomy, as done in previously established nonunion models. The femur was stabilized with a retrograde, intramedullary Kirschner wire (K-wire). As a control, 24 additional rats received K-wire fixation but no osteotomy was created. Rats were sacrificed at 3, 7, 14, and 28 days at which point blood was drawn and the femur excised. SELDI-TOF (surface-enhanced laser desorption ionization time-of-flight) mass spectrometry (MS) analysis was used to identify biomarker expression in the serum. Histology and micro-CT were used to characterize and quantify bone mineralization and density, respectively, to correlate these parameters to biomarker expression.

Results: Results demonstrated several differentially expressed biomarkers in rat serum of bone healing versus control rats and throughout the course of healing. Relevant biomarkers, known to play a role in osteogenesis were insulin-like growth factor II (IGF-II) and parathyroid hormone-related protein (PTHrP). Both biomarkers showed systemic upregulation at 7 days postosteotomy, and significantly greater expression in bone healing rats than control rats at 7, 14, and 28 days postsurgery ($P < 0.05$) (Figure 1). Histology and micro-CT confirmed an increase in callus mineralization in healing rats and little to no bone remodeling in nonunion rats.

See pages 91 - 132 for financial disclosure information.

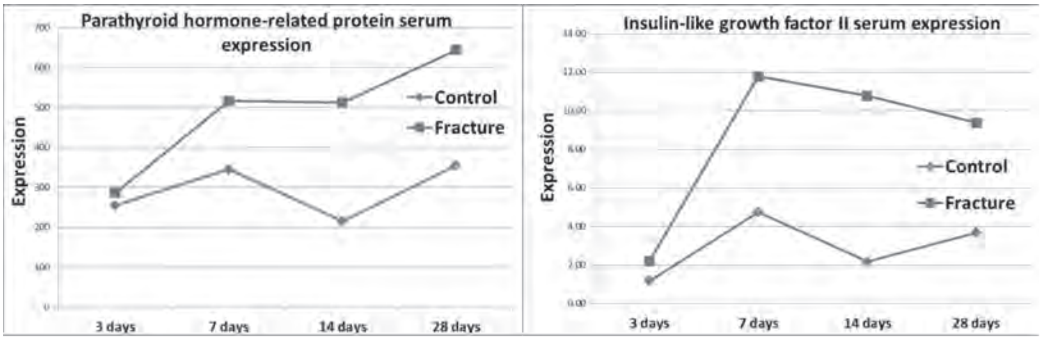

Figure 1. Serum expression of IGF-II and PTHrP in control and healing osteotomy rats 3, 7, 14, and 28 days postsurgery.

Conclusion: Results indicate that specific biomarkers associated with bone healing fluctuate in systemic expression throughout the progression of bone healing and are measurable with SELDI-TOF MS. Protein expression in nonunion rats is currently being analyzed. If biomarkers that correlate to fracture healing can be measured from serum, they can be used to monitor bony union prospectively, potentially reducing patient exposure to radiation from CT and radiographs. The findings may also have a broader impact in characterizing the biologics of fracture healing, which can be used for further development of biologic-based treatment modalities.

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BSFF SYMPOSIUM 4:
BUILDING NETWORKS: THE BASICS

Moderators: *Saam Morshed, MD, PhD*
Paul Volberding, MD

3:45 pm **Global Clinical Research: Why Do We Need It?**
Paul Volberding, MD

4:00 pm **What Kind of Evidence is Needed to Change Practice or Policy?**
David Shearer, MD, MPH

4:10 pm **Conducting International Clinical Research:**
What Resources are Necessary?
Emil H. Schemitsch, MD

4:20 pm **Selecting the Right Study Design: Balancing Science and Resources**
Saam Morshed, MD, PhD

4:30 pm **International Research Studies: How to Partner?**
Gerard P. Slobogean, MD, MPH

4:40 pm Discussion

NOTES

See pages 91 - 132 for financial disclosure information.

Management of Closed Femur Fractures with the SIGN Intramedullary Nail in Two Developing African Countries

Kyle R. Stephens, DO[1]; *Daniel Galat, MD*[2]; *Duane Anderson, MD*[3]; *Kiprono G. Koech, MD*[2]; *Paul Whiting, MD*[4]; *Michael Mwachiro, MD*[2]; *Douglas W. Lundy, MD*[5];
[1]*Henry Ford Macomb Hospital, Clinton Township, Michigan, USA;*
[2]*Tenwek Hospital, Bomet, Kenya;*
[3]*Soddo Christian Hospital, Soddo, Ethiopia;*
[4]*Tufts University, Boston, Massachusetts, USA;*
[5]*Resurgens Orthopaedics, Marietta, Georgia, USA*

Purpose: The Surgical Implant Generation Network (SIGN) intramedullary nail was designed for use in developing settings that often lack fluoroscopy or power instrumentation. Our purpose was to evaluate the clinical and radiographic outcomes of closed femoral shaft fractures fixed with the SIGN nail in two developing African countries.

Methods: Data from the SIGN online database was reviewed for all closed femur fractures treated with the SIGN nail at two mission hospitals in sub-Saharan Africa. Demographics, time to surgery, fracture classification (AO/OTA), antegrade versus retrograde approach, open versus closed reduction, number of follow-ups, time to union, and complications were recorded. Only patients with at least one follow-up visit were included in the analysis.

Results: Between September 2008 and November 2012, 471 patients were treated with the SIGN nail for closed femur fractures. Of these, 235 patients (240 fractures) returned for at least one postoperative visit. Average age was 43.3 years (Range 14-87). Average time from injury to fracture fixation was 6.1 days (Range 0-60 days). Nails were placed antegrade in 137 fractures (57%) and retrograde in 103 fractures (43%). Open reduction was performed in 208 cases (87%). Average length of follow-up was 99.7 days (range 15-838 days). Average number of follow-up visits per patient was 1.6. Average time to union was 96.1 days (Range 21-707 days) for those patients (154 fractures, 64%) with enough follow-up to show radiographic union. Overall, 26 complications occurred in 23 patients (9.6%). The most common complication after retrograde nailing was knee stiffness, representing 7 of 14 complications (50%) in this group. Varus mal-union of proximal femoral shaft fractures accounted for 5 of 12 complications (42%) after antegrade nailing. Other complications included deep infection in four patients (1.5%), nonunion in three patients (1%), and peri-prosthetic fractures at the proximal tip of the nail after retrograde nailing in two patients (0.8%). Revision surgery was performed in 12 patients (5%).

Conclusion: Closed femur fractures can be managed successfully in developing countries using the SIGN nail with acceptable rates of complications and reoperation. Predictable complications related to surgical approach and fracture location were observed. Although radiographic union was confirmed in only 64% of fractures, many patients were lost to follow-up prior to the time of expected radiographic union. Known geographic and financial barriers common in the developing world create a disincentive for asymptomatic patients to return for routine follow-up visits. Low rates of deep infection and nonunion were seen despite the fact that open reduction was performed in the vast majority of cases. These favorable outcomes further support the utility of the SIGN nail for intramedullary fixation of closed femur fractures in the developing world.

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Δ The Design of a Prospective Observational Study to Evaluate the Outcomes of Operatively Treated Femoral Shaft Fractures in Sub-Saharan Africa

***David Shearer, MD, MPH*[1]**; *Edmund Eliezer, MD*[2]; *Billy Haonga, MD*[2];
Saam Morshed, MD, PhD[1];
[1]*University of California, San Francisco, California, USA;*
[2]*Muhimbili Orthopaedic Institute, Dar es Salaam, Tanzania*

Purpose: We designed a prospective study to compare the outcomes of intramedullary nailing and plate fixation of femoral shaft fractures at a tertiary referral center in Sub-Saharan Africa. In the current study, we aim to describe the design of this prospective investigation, the challenges discovered during implementation, and the novel approaches used to successfully conduct a clinical study in a low-resource environment.

Methods: The study design is a prospective observational study enrolling skeletally mature patients with OTA type-32 femoral shaft fractures who undergo surgery at a single center in Sub-Saharan Africa. The primary outcome is reoperation, and secondary outcomes are EQ-5D (EuroQol), clinical and radiographic union, and return to work. Our power analysis suggested that 330 patients would be needed to address the primary hypothesis. Follow-up data are collected at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year postoperatively. Incentives to encourage follow-up include (1) free follow-up care, (2) a dedicated Saturday research clinic, (3) phone and SMS (text messaging) appointment reminders, and (4) transportation (for 1-year follow-up only). All data entry is performed using portable laptops with secure, web-based data entry using Research Electronic Data Capture (REDCap). Images of plain radiographs are collected and transmitted electronically using mobile phones with customized data entry forms using Open Data Kit (ODK). There are two part-time local research coordinators and two primary investigators at the local site. The study was approved by the ethical review board of both the US institution and the Ministry of Health in Tanzania.

Results: In the first year after initiating the study, we have enrolled 313 patients (719 radiographically screened, 331 clinically screened, 313 enrolled). The population consists primarily of young (mean age, 31.7 years) men (88.9%) with isolated femoral shaft fractures suffered in road traffic accidents (79.2%) treated with open reduction and locked medullary nailing without C-arm. The follow-up rate at 6 months is 69% (99/144). The two part-time local research coordinators are able to successfully manage the day-to-day operations of the study including electronic data entry and patient follow-up coordination. Important challenges overcome include navigating the local IRB, training local coordinators, and subcontract initiation. The most common reasons for loss to follow-up include the failure to collect accurate contact information at baseline and lack of transportation.

Conclusion: Medical centers in many low-income countries treat an extremely high volume of traumatic injuries, but there is very little research from these settings to guide treatment decisions. We have designed a prospective study to determine the outcomes of femoral shaft fractures, with successful enrollment and short-term follow-up despite the high clinical volume and shortage of resources. The collaborative effort between institutions has fostered locally appropriate solutions that we believe can serve as a model to inform future studies.

Δ OTA Grant
See pages 91 - 132 for financial disclosure information.

International Randomized Control Trial: FLOW
Kyle J. Jeray, MD

NOTES

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BSFF SYMPOSIUM 5: INFECTION

Moderators: *Emil H. Schemitsch, MD*
Joseph C. Wenke, PhD

7:30 am **Diagnosis of Infection in Orthopaedic Trauma Patients: New Technologies**
Joseph C. Wenke, PhD

7:40 am **Preventing Orthopaedic Infections**
David Markel, MD, MPH

7:50 am **Implant-Related Infections: Bugs and Biofilms**
Lawrence X. Webb, MD

8:00 am **Managing Hardware-Related Infections: Evidence Based Strategies**
Michael D. McKee, MD

8:10 am **Treatment of Post-Traumatic Osteomyelitis: The Next Generation!**
Todd O. McKinley, MD

8:20 am Discussion

NOTES

See pages 91 - 132 for financial disclosure information.

Development and Evaluation of a Biofilm Dispersing Scaffold

Carlos J. Sanchez Jr, PhD[1]; Edna M. Prieto, PhD[2,3]; ***Chad A. Krueger, MD[1]****;*
Katarzyna J. Zienkiewicz, PhD[3]; Desiree R. Romano, BA[1]; Kevin S. Akers, MD[1]; S. K. Hardy[1], Ronald L. Woodbury[1],Scott A. Guelcher[2,3,4]; Joseph C. Wenke, PhD[1];
[1]United States Army Institute of Surgical Research, Department of Extremity Trauma and Regenerative Medicine, Fort Sam Houston, San Antonio, Texas, USA;
[2]Department of Chemical and Biomolecular Engineering, Vanderbilt University, Nashville, Tennessee, USA;
[3]Center for Bone Biology, Vanderbilt University Medical Center, Nashville, Tennessee, USA;
[4]Department of Biomedical Engineering, Vanderbilt University, Nashville, Tennessee, USA

Background/Purpose: Open fractures are universally contaminated, leading to bone and hardware infections and decreased osseous union. Biofilm formation is a central event contributing to the development of chronic infections; moreover, it has been linked to nonosseous union in up to as many as 67% of patients with negative cultures. Thus, antibiofilm agents have recently gained considerable interest as therapeutics for contaminated wounds. This study investigates the spectrum of activity of biofilm dispersal activity of D-amino acids (D-AAs) on clinical isolates of *Staphylococcus aureus* and toxicity to human cells in vitro. We also investigated whether local delivery of D-AAs from biodegradable polyurethane scaffolds with D-AAs could reduce infection in a contaminated segmental defect model.

Methods: Human fibroblasts and osteoblasts were exposed to individual D-AAs in vitro to assess toxicity. The ability of D-AAs, individually or as a mixture, to disrupt and prevent biofilm formation in a collection of clinical wound isolates of *S. aureus* and *Pseudomonas aeruginosa* was evaluated using the conventional 96-well plate microtiter model. D-AAs most effective at preventing biofilm formation (D-Met, D-Pro, and D-Trp) were then embedded into polyurethane scaffolds (PUR) in a 1:1:1 ratio. Porosity of the scaffolds and the release kinetics of the D-AAs were determined using scanning electron microscopy and high performance liquid chromatography, respectively. The embedded PURs were then tested in vivo against two strains of *S. aureus*, Xen36 (low-biofilm producer), and UAMS-1 (high-biofilm producer recovered from an osteomyelitis patient) in a previously characterized contaminated critical-size rat femur defect that utilized systemic, postoperative antibiotics.

Results: D-AAs were observed to have minimal toxicity on the viability of human osteoblasts and fibroblasts. D-Phe, D-Met, D-Trp, and D-Pro were found to be the most effective at dispersing and preventing biofilm formation. Combining D-Pro, D-Met, and D-Trp enhanced these effects and adding cefazolin to the D-AA decreased the MBEC (minimal biofilm eradication concentration) of the *S. aureus* by 16-fold. D-AAs varied in their release from PURs with 60% of D-Met but only 25% of D-Trp being released on day 1. All D-AAs had close to 100% release by 30 days. The D-AA-embedded PUR significantly ($P < 0.05$) reduced the microbial burden within the contaminated, critical-size defects when compared to empty PUR scaffolds with the biofilm forming the UAMS-1 *S. aureus.* There was no reduction seen when the wound was contaminated with the low-biofilm forming Xen-36 *S. aureus*.

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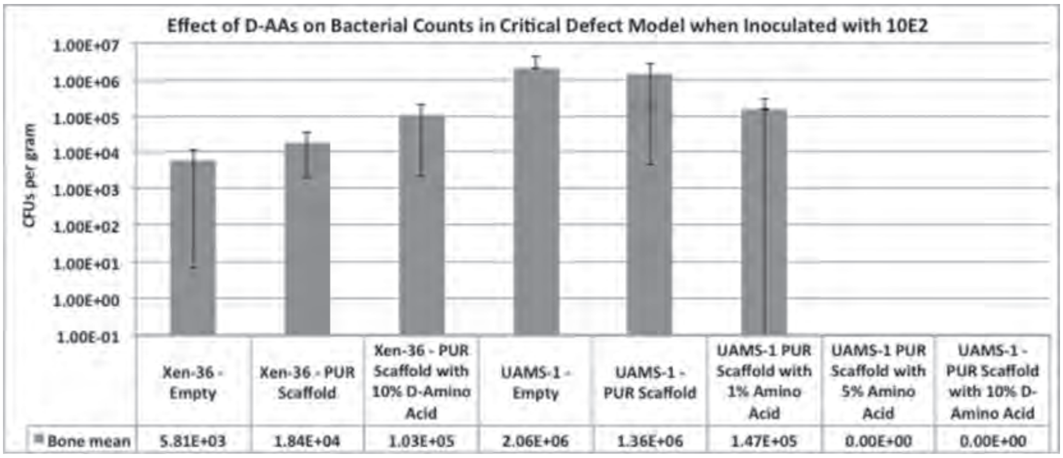

Conclusion: The vast majority of chronic infections are caused by biofilm-forming bacteria. Our results suggest that D-AAs have a broad spectrum and that local delivery of D-AAs reduces the biofilm and can enhance the activity of antibiotics against biofilms.

PAPER ABSTRACTS

See pages 91 - 132 for financial disclosure information.

Intraoperative Dip-coating Inhibits Biofilms and Supports Bone Healing During Infection

Thomas P. Schaer, DO*; Suzanne Stewart, DVM;*
University of Pennsylvania School of Veterinary Medicine, Kennett Square, Pennsylvania, USA

Background/Purpose: Today, implant-associated infections contribute to increased patient morbidity and cost. Adhesion of serum proteins to the implant and low vascularity in the area of trauma create an ideal environment for bacterial adherence. Within a biofilm, bacteria synthesize an extracellular matrix that protects them from the host's immune response and systemic antimicrobials. Importantly, bacterial colonization onto substrates appears to be one critical step in biofilm formation. Consequently, we have focused our attention on surface modifications that inhibit the adherence of bacteria to implants and thereby prevent the root cause of orthopaedic infections. We hypothesized that coating orthopaedic fracture plates with certain hydrophobic polycations could favorably influence bone healing in a large animal fracture infection model.

Methods: 12 mature female sheep were enrolled in a prospective study using a previously validated long bone infection model. A unilateral middiaphyseal transverse tibial osteotomy was performed and reduced using a narrow 4.5-mm 8- or 9-hole stainless steel 316L locking compression plate (LCP). After soft-tissue closure, 10^6 CFUs (colony-forming units) of *Staphylococcus aureus* ATCC25923 were inoculated via a temporary catheter. Six sheep received coated implants (treatment cohort) and the remaining six animals received non-coated implants (control cohort). Implants were dip-coated intraoperatively. Radiographs, obtained immediately postoperative and at the conclusion of the study (30 days postoperative), were scored by three blinded reviewers for presence of septic osteomyelitis and callus morphology. The left hind limb was harvested and aseptically prepared for implant retrieval. A sterile culture was taken before implant removal. Tibias underwent micro-CT for qualitative 3-dimensional reconstructions. The osteotomy region was harvested and processed for histology and sections were scored by a blinded veterinary pathologist. Plate pieces were processed for scanning electron microscopy (SEM) and viewed for evidence of bacterial colonization. Statistical analyses were carried out on scores from radiographic, histologic, and explant evaluations. A paired *t* test was used to form preliminary associations and a statistical significance of $P < 0.05$ was used for all tests.

Results: All animals completed the study. Radiographic evaluation revealed significantly greater healing and bony remodeling consistent with normal "fracture healing" in treatment animals compared to controls ($P < 0.05$). Gross evaluation revealed the osteotomy sites in control animals to be grossly unstable with evidence of infection ($P < 0.05$). Micro-CT and histological evaluation corroborated radiographic and macroscopic data with lower scores in treatment when compared to controls ($p<0.05$) consistent with normal bone healing. SEM visualization of explanted LCPs displayed abundant biofilm formation covering >95% of the plate surface in control plates compared with no bacterial growth on coated implants.

Conclusion: Advantages of this surface modification are (1) the ease with which the coating can be applied intraoperative to any geometry implant and (2) death of the bacteria

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by mechanical disruption of the cell wall, which is less likely to create multidrug resistant bacteria. Conferring protection from pathogenic bacteria to an orthopaedic implant of industrial size and geometry in vivo is promising for reducing implant-associated infections in the orthopaedic patient.

See pages 91 - 132 for financial disclosure information.

Evaluation of an Absorbable Gentamicin-Eluting Plate Sleeve in an Ovine Fracture Healing Model

Joanne Haughan, DVM[1]*; C. Alex DePaula, PhD*[2]*; David Armbruster, BS*[2]*;*
Thomas P. Schaer, DO[1]*;*
[1]*University of Pennsylvania School of Veterinary Medicine, Kennett Square, Pennsylvania, USA;*
[2]*DePuy Synthes - Biomaterials, West Chester, Pennsylvania, USA*

Background/Purpose: Lower extremity fractures have been associated with surgical site infection (SSI) and osteomyelitis. Implants can serve as substrates for bacterial adhesion and formation of bacterial biofilm, increasing the risk of surgical site infections. The recent development of an antibacterial plate sleeve (APS) allowing for controlled local delivery of gentamicin, shows great promise in mitigating SSIs. The purpose of this study was to evaluate the effect of the APS on fracture healing using a large animal fracture healing model.

Methods: 48 skeletally mature ewes underwent a unilateral mid-diaphyseal tibial osteotomy repaired with a locking plate. The tubular polymer plate sleeve was fitted over the plate for the treatment cohorts (1 APS or 4 APS) while control cohorts (Cx) received no sleeve. Sheep were euthanized at 4 and 12 weeks postoperatively. Outcome measures included: blood counts, serum chemistry, gentamicin plasma concentration, lameness scoring, and radiography for the in vivo phase. Explanted tibiae were analyzed using micro-CT, histopathology, and a semiquantitative scoring to evaluate bone healing at the osteotomy site.

Results: Surgical procedures were without complications and all animals had uneventful anesthetic recoveries. One sheep sustained a catastrophic failure of the repair and was eliminated from the study. No abnormal findings were noted for clinical pathology, serum chemistry, and gross necropsy observations in any of the study cohorts. Both treatment groups showed a peak serum concentration of gentamicin at 1 to 4 hours, with detectable gentamicin plasma concentration up to 10 days at 10.50 ± 6.98 ng/mL. The highest concentration measured was a maximum plasma gentamicin concentration of 781 ng/mL. There were no significant differences in radiographic scores between 1 APS, 4 APS, or Cx cohort at 12 weeks; there was a significant difference between 1 APS, 4 APS, and Cx for the 4-week cohort (P <0.05). There was no significant effect of treatment (1 APS, 4 APS) on lameness scores and all clinical observations were unremarkable. Macroscopic evaluation of the tibial osteotomy sites, including the soft-tissue envelope, was unremarkable. Micro-CT analysis corroborated normal bone healing and there were no statistical differences found among the 3 treatment groups (1 APS, 4 APS, or no sleeve). All osteotomy scores at all sites (cranial, caudal, lateral) were significantly increased with time and significantly affected by time, confirming the progression of healing between 4 and 12 weeks. The osteotomy scores were also significantly lower in group 1 APS than in group Cx at 12 weeks only, but was not significantly different between group 4 APS and group Cx. Histopathology evaluation of the soft tissues surrounding the plate and screws showed no treatment-dependent variations except for the presence of the polymer sleeve and an associated low-grade chronic foreign body response. Polymer remnants of the APS implant were observed at 4 weeks postoperative but bioresorption was mostly completed by 12 weeks.

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Conclusion: In summary, clinical observations, digital radiography, and multiple additional ex vivo analytical methods indicated that the APS technology applied to commercially available fracture hardware in this preclinical large animal model is safe.

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BSFF SYMPOSIUM 6: STEM CELL THERAPIES

Moderators: *Theodore Miclau, III, MD*
Ralph S. Marcucio, PhD

9:30 am **Stem Cell Populations: Which Ones are Most Useful?**
Aaron Nauth, MD

9:40 am **Stem Cells: How Do They Influence Healing?**
Peter V. Giannoudis, MD

9:50 am **Progenitor Cells: What are the Sources?**
Ralph S. Marcucio, MD

10:00 am **Stem Cell Therapies: What Still Needs to be Overcome?**
Chelsea Bahney, PhD

10:10 am **Developing Stem Cell Approaches to Bone Defect**
George F. Muschler, MD

10:20 am Discussion

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Δ Effects of Endothelial Progenitor Cell Therapy on Diabetic Rat Fracture Healing

Clifford Lin, MD*; Aaron Nauth, MD, FRCSC; Emil H. Schemitsch, MD, FRCSC;*
University of Toronto, St. Michael's Hospital, Toronto, Ontario, Canada

Background/Purpose: There has been substantial interest in tissue engineering strategies that employ the use of stem/progenitor cells for the treatment of bone defects and bone loss in orthopaedic patients. Furthermore, several studies have shown increased complications with bone healing in patients with associated comorbidities such as diabetes. The effectiveness of tissue engineering strategies in these healing-compromised hosts is not well understood. This study sought to investigate the effects of an endothelial progenitor cell (EPC) type on a model of impaired fracture healing, using a diabetic rat model.

Methods: EPCs were isolated from rat bone marrow, cultured for 10 to 14 days in endothelial cell culture media, then harvested and reimplanted into either a control rat fracture model or a diabetic rat fracture model. This model consisted of creating a 3-mm segmental bone defect in the right femur then filling the defect with an empty gelfoam scaffold (control treatment) or EPC-seeded gelfoam. The femur was then stabilized with a plate and screw construct and the rat allowed to bear weight as tolerated. Rats were then sacrificed at 10 weeks and the femurs harvested then submitted for clinical and radiological analysis. In the diabetic group, diabetes was induced via intraperitoneal injection of 35 mg/kg of streptozotocin 2 weeks prior to creation of the bone defect. Hyperglycemia was confirmed with glucometer testing on a regular basis throughout the study period.

Results: In control (nondiabetic) rats, 0 of 8 rats (0%) that were implanted with gelfoam only went on to radiographic union. Of those that were implanted with EPC-seeded gelfoam, 5 of 8 (62.5%) were healed. In diabetic rats, 0 of 10 (0%) with implanted gelfoam only went on to radiographic union. Of those implanted with EPC-seeded gelfoam, 5 of 12 (41.7%) went on to heal.

Conclusion: Implantation of EPCs into bony defects can increase the incidence of union in segmental bony defects. This effect is seen in both healthy control rats as well as healing-compromised diabetic rats, although the incidence of union is lower in the diabetic group. Continued research in this area is required to identify effective therapies for the enhancement of fracture vascularity and bone regeneration.

Δ OTA Grant

See pages 91 - 132 for financial disclosure information.

The Effects of Aminobisphosphonate In Vitro and In Vivo Treatment on the Osteogenic Capacity of Bone Marrow Stromal Cells from Senile Osteoporotic Hip Fracture Patients

***Richard A. Lindtner, MD*[1]**; *André N. Tiaden, PhD*[2]; *Konstantin Genelin, MD*[1]; *Hannes L. Ebner, PhD*[1]; *Ingrid Sitte, MD*[1]; *Marina Klawitter*[2]; *Prof. Brigitte von Rechenberg, DVM*[2]; *Prof. Michael Blauth, MD*[1]; *Peter J. Richards, PhD*[2];
[1]*Department for Trauma Surgery and Sports Medicine, Medical University of Innsbruck, Innsbruck, Austria;*
[2]*Bone and Stem Cell Research Group, Competence Center for Applied Biotechnology and Molecular Medicine, University of Zurich, Zurich, Switzerland*

Purpose: Aminobisphosphonates (BPs) prevent age-related bone loss and osteoporosis-associated fractures through the inhibition of osteoclast resorptive activity. However, the effects of these potent synthetic compounds on cells of the osteoblastic lineage of senile osteoporotic patients is unclear so far, although resident bone marrow stromal cell (BMSC) populations are known to play a critical role in determining bone quality. The purpose of this study therefore was to determine whether both zoledronate (ZA) in vitro and alendronate (ALN) in vivo treatment enhance the osteogenic differentiation capacity of BMSCs obtained from senile osteoporotic hip fracture patients.

Methods: BMSCs were intraoperatively harvested from 7 senile osteoporotic hip fracture patients not receiving BP therapy and from 3 patients receiving alendronate therapy. BMSCs were cultured in osteogenic medium ± ZA (10 and 100 nM) for up to 21 days. The effects of ZA in vitro treatment on BMSC viability and proliferation were evaluated using Annexin-V/PI FACS (flow cytometry) analysis and WST-1 assay, respectively. The effect of ZA on osteogenic differentiation was assessed using Alizarin Red staining, alkaline phosphatase (ALP) enzyme activity, and quantitative real-time polymerase chain reaction (qRT-PCR) of osteogenic marker genes. Furthermore, osteogenic potential of BMSCs obtained from 3 patients receiving ALN therapy in vivo and from 3 matched controls without BP therapy were compared.

Results: In vitro exposure to ZA (10 and 100 nM) up to 72 hours did not significantly affect BMSC viability and proliferation. BMSCs cultured in osteogenic medium supplemented with ZA (10 and 100 nM) for 21 days showed a significant increase in mineralized matrix formation as assessed by Alizarin Red staining when compared to BMSCs cultured in osteogenic medium alone (P <0.01). However, no significant differences were found for ALP enzyme activity and gene expression levels of osteogenic markers ALP, bone sialoprotein (IBSP), and basic fibroblastic growth factor (FGF2). Similarly, BMSCs obtained from osteoporotic hip fracture patients receiving ALN treatment in vivo also showed a markedly enhanced mineral deposition as compared to BMSCs obtained from matched osteoporotic controls not receiving bisphosphonate therapy (P <0.01).

Conclusion: Our results for the first time show that aminobisphosphonate in vitro and in vivo treatment enhances osteoblastogenesis and subsequent mineralized matrix formation of osteoporotic BMSCs and thus supports an osteoanabolic effect of bisphosphonates in senile osteoporosis.

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PAPER ABSTRACTS

Healing Segmental Bone Defects With Endothelial Progenitor Cell Subtypes

Erica Giles, BS[1]; *Michael Glick, BSc*[1]; *Tony Lin, BSc*[1]; *Wendy Chi*[1]; *Aaron Nauth, MD*[1,2]; *Emil H. Schemitsch, MD*[1,2];
[1]*Musculoskeletal Laboratory, St. Michael's Hospital, Toronto, Ontario, Canada;*
[2]*Department of Surgery, Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada*

Purpose: Angiogenesis is critical for osteogenesis, and vascular cell-based therapy can be used to stimulate healing in segmental bone loss. The purpose of the study was to compare early endothelial progenitor cells (EPCs) and late outgrowth endothelial progenitor cells (OEC) for fracture healing potential in vitro and in vivo.

Methods: Primary EPC subtypes were isolated from rat marrow via Ficoll density gradient centrifugation. Endothelial assays, immunosorbent assays, and multicolor flow cytometry for population surface markers (CD11, CD31, CD34, CD45, CD133, and Flk-1) were used to characterize EPC and OEC monocultures. Cocultures of EPC subtypes with and without primary rat osteoblasts (pObs) were analyzed for tube length and connectivity using Image J to evaluate cell-cell effects on angiogenic potential. In vivo, EPCs or OECs (1×10^6) were seeded to gelfoam scaffold and implanted in a critical-size (4-mm) fixed diaphyseal defect in a rat femur; control animals received empty scaffold in the defect. Radiography was used to monitor bone formation over 10 weeks.

Results: OECs expressed significantly more bone morphogenetic protein (BMP)-2 and significantly less vascular endothelial growth factor (VEGF) than EPCs (P <0.05). Surface marker analysis showed decreased CD34+/CD133+/Flk-1+ (48% EPCs vs 22% OECs), CD133+ (77% EPCs vs 13% OECs), and CD45+ (46% EPCs vs 2.6% OECs) populations in OECs while the CD34+/CD31+/Flk-1+ (33% EPCs vs 49% OECs) population increased. pObs significantly inhibited tubulogenesis of OECs while enhancing connectivity and sprout length of EPCs in coculture (P <0.05). In vivo, 0 of 6 control and 1 of 5 OEC rats achieved partial union at 10 weeks while 4 of 5 EPC rats achieved full union at this time point.

Conclusion: Despite favorable tubulogenic and osteoinductive profiles of OEC monoculture, EPCs displayed enhanced tubulogenic behavior in coculture and superior bone healing in vivo. No previous studies have directly compared subtypes of this novel progenitor population for healing bone defects. The results suggest an early EPC subtype may be more biologically pertinent for this application.

See pages 91 - 132 for financial disclosure information.

Final Program

29th Annual Meeting

2013 OTA ANNUAL MEETING OCT. 9-12

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SYMPOSIUM I: EVALUATING OUTCOMES IN THE 21st CENTURY

Moderator: *Mark S. Vrahas, MD*

Faculty: *Richard C. Gershon, PhD*
Thomas F. Higgins, MD
Nan Rothrock, PhD

1:20 pm	**History, Organization, and Status of NIH PROMIS Initiative** *Nan Rothrock, PhD*
1:35 pm	Questions and Discussion
1:45 pm	**Introduction to Item Response Theory and Computer Adaptive Testing** *Richard C. Gershon, PhD*
2:05 pm	Questions and Discussion
2:15 pm	**Introduction to Assessment Center - Research Tool for PROMIS Instruments** *Nan Rothrock, PhD*
2:25 pm	Questions and Discussion
2:30 pm	**Early Experience Using PROMIS Tools with Orthopaedic Patients** *Thomas F. Higgins, MD*
2:45 pm	Questions and Discussion

NOTES

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Time to Definitive Operative Treatment Following Open Fracture Does Not Impact Development of Deep Infection: A Prospective Cohort Study of 736 Subjects

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Purpose: The primary study objective was to evaluate the relationship between time to definitive orthopaedic surgical management and development of deep infection in open long bone fractures (humerus, radius/ulna, femur, tibia/fibula). Secondarily, we examined the association of Gustilo grade and fracture location with development of deep infection.

Methods: Between 2001 and 2008, 736 subjects with 791 open fractures were enrolled in a prospective cohort study undertaken at three Level I trauma centers. Demographics, injury information (Gustilo grade, fracture site), and time from injury to definitive surgical management were recorded. Subjects were evaluated at outpatient clinics using standardized data forms until the fracture healed. Phone interviews were undertaken at 1 year postfracture to confirm outcomes. Deep infection was defined as purulent drainage or osteomyelitis presenting after wound closure. Descriptive analyses were initially undertaken on time from injury to definitive surgical management calculated in hours, Gustilo grade, and fracture location (upper extremity, femur, tibia/fibula). Multivariate logistic regression was undertaken on time from injury to surgery, Gustilo grade and fracture location with deep infection (yes/no) as the dependent variable.

Results: Most subjects were male (n = 530 [72%]) and the mean age was 41.5 ± 17.1 years. Almost half (n = 359 [49%]) of injuries occurred in motor vehicle accidents; falls (n = 230 [31%]), crush injuries (n = 131 [18%]) and assaults (n=16 [2%]) were other mechanisms of injury. Tibial/fibular fractures were most common (n = 413 [52%]), followed by upper extremity (n = 285 [36%]) and femoral (n = 93 [12%]) fractures. Overall, 636 (86%) subjects (685 fractures) completed the 1-year interview; only 39 (5%) subjects (43 fractures) did not complete either clinic visits or the 1-year interview. Of 753 fractures with outcomes, 46 (6%) developed deep infections. The mean time to surgery was 10.9 ± 10.6 hours for those without and 8.7 ± 4.4 hours for those with deep infection ($P = 0.17$). Of those with infection, 9 (21%) underwent surgery within 6 hours, 28 (65%) between 6 and 12 hours, and 6 (14%) after 12 hours of injury. In general, time to operating room (OR) decreased as Gustilo grade increased ($P < 0.001$) while infections increased with increasing Gustilo grade ($P < 0.001$).

Gustilo Grade	Mean Time to OR ± SD*	Deep Infection	No Infection
Grade 1 (n = 220)	13.6 ±16.8 hours	2 (1%)	210 (99%)
Grade 2 (n = 284)	9.9 ± 5.3 hours	12 (4%)	265 (96%)
Grade 3A (n = 159)	10.0 ± 6.1hours	15 (10%)	143 (90%)
Grade 3B (n = 92)	8.7 ± 3.8hours	16 (17%)	76 (83%)
Grade 3C (n = 7)	9.9 ± 4.3 hours	1 (17%)	5 (83%)

*SD = standard deviation.

See pages 91 - 132 for financial disclosure information.

Four (1.5%) upper extremity, seven (8%) femoral, and 34 (9%) tibial/fibular fractures developed deep infections ($P = 0.001$). Multivariate logistic regression showed no significant association between developing deep infection and mean hours to operative management (odds ratio [OR] 0.97; 95% confidence intervals [95% CI] 0.90, 1.1) while Grades 3A (OR 6.6; 95%CI 1.5, 30.2) and 3B (OR 13.4; 95%CI 2.9, 61.9) relative to Grade 1 injuries and tibia/fibular (OR 4.0; 95%CI 1.4, 11.8) relative to upper extremity fractures were significantly associated with developing deep infection.

Conclusion: Development of deep infection after open fracture was not associated with time to surgery; instead increasing Gustilo grade or tibial/fibular fractures were associated with developing a deep infection. With the low number of infections seen in Grade 1 and 2, and all upper extremity open fractures, there may be clinical implications for determining if an open fracture requires surgery in the middle of the night, especially if a trauma room is available in the morning.

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Pain and PTSD Following Major Extremity Trauma: Results from the METALS Study

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Background/Purpose: Soldiers injured in Iraq and Afghanistan experience significant rates of chronic pain and posttraumatic stress disorder (PTSD), and major limb injuries are a primary cause of disability in this population. However, the extent to which pain and PTSD drive disability among veterans who have experienced major limb injuries is not known. This study was undertaken to assess the burden and co-occurrence of pain and PTSD among service members who sustained a major limb injury while serving in Afghanistan or Iraq, and examine the extent to which these conditions are associated with functional outcomes.

Methods: METALS (Military Extremity Trauma Amputation/Limb Salvage) is a retrospective cohort study of 429 United States service members who sustained major limb injuries (defined as one or more of the following: traumatic amputation, revascularization, bone graft or transport, local or free flap coverage, complete deficit of a major nerve, or compartment syndrome) while serving in Afghanistan or Iraq. Outcomes assessed by telephone interview (mean 38 months postinjury) were: function using the Short Musculoskeletal Functional Assessment (SMFA); PTSD using the PTSD Checklist (PCL) and Diagnostic and Statistical Manual (DSM) criteria; and pain using the Chronic Pain Grade Scale.

Results: As previously reported, significant long-term pain was observed in this population (mean pain: 49.8 ± 22.8), as well as a high prevalence of PTSD (25% met both the PCL and DSM criteria). As shown in the table below, there was a marked relationship between report of pain and PTSD and functional outcome. The age- and gender-adjusted population norm for SMFA dysfunction is 5.4 ± 9.8 and the proposed minimally clinically important difference (MCID) for this measure is 6. The results suggest METALS patients without pain or PTSD were, on average, about one MCID from age- and gender-adjusted population norms. In contrast, METALS patients with low levels of pain and no PTSD were, on average, two MCIDs from population norms. METALS patients with either greater levels of pain, PTSD, or both, were three to four MCIDs from population norms. Regression analyses adjusted for injury type, age, time to interview, military rank, social support, mild TBI (traumatic brain injury)/concussion, and combat experiences showed large, significant effects for both pain and PTSD on 1-year functional outcomes.

Conclusion: Major limb trauma sustained in the military results in significant long-term pain and PTSD. Overall, the results are consistent with the hypothesis that pain and PTSD are major drivers of disability in this population. The correlational nature of the data does not permit ruling out the alternative hypothesis, that function is driving PTSD and pain. However, prior analyses and theory suggest this alternative hypothesis is less likely.

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SMFA Dysfunction [n, mean (95% confidence interval)] by PTSD status and Chronic Pain Grade

	No Pain	Low Pain (<50) Intensity, No Interference	High Pain (≥50) Intensity, No Interference	Low Pain (<50) Intensity, High Interference	High Pain (≥50) Intensity & Interference
No PTSD	n = 31 10.6 (7.3, 13.9)	n = 141 16.8 (14.9, 18.7)	n = 127 25.1 (22.9, 27.3)	n = 39 35.5 (32.0, 39.0)	n = 5 40.9 (27.3, 54.5)
PTSD	n = 1 41.9 (N/A)	n = 8 33.9 (24.4, 43.4)	n = 31 33.2 (27.7, 38.6)	n = 26 42.7 (38.3, 47.1)	n = 15 55.6 (50.9, 60.2)

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The Effectiveness of an Osseointegrated Prosthesis Compared With Socket Prosthesis After Transfemoral Amputation

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Purpose: The purpose of this study is to evaluate the functional efficacy of an osseointegrated leg prosthesis (ILP) as compared to conventional sleeve prosthesis.

Methods: In this prospective case-control study, 22 consecutive patients were included after transfemoral amputation (one bilateral) with demonstrable socket-related skin and stump problems resulting in limited prosthetic use. The mean age was 46.5 years (range, 23-67 years) and the mean time after the amputation was 16.4 years (range, 2-45). The cause of amputation was traumatic in 20 and a malignancy in 2 cases. All patients underwent surgical treatment with implantation of an osseointegrated prosthesis (ILP; Ortho Dynamics GmbH, Lubeck, Germany) in two sessions. The primary outcome measure was the validated questionnaire for persons with a transfemoral amputation (Q-TFA) after 1 year. Secondary outcome measures were prosthetic use, 6-minute walking test, timed stand up and go test, and oxygen consumption on the treadmill measured after 1 year.

Results: With a socket prosthesis the Q-TFA showed a mean global score of 38.5 points (standard deviation [SD] 4.7). One year after implantation of the ILP this was 62.6 (SD 5.3). Prosthetic use, the 6-minute walking test, the timed stand up and go test, and oxygen consumption were 55.7 hours per week (SD 7.9), 321 m (SD 28), 15.1 sec (SD 2.1), and 1330 mL/min/kg (SD 310). One year after implantation of the ILP, a significant improvement was registered on all these parameters respectively: 100.9 hours per week (SD 2.4), 423 m (SD 21), 8.1 sec (SD 0.7), and 1093 mL/min/kg (SD 361).

Conclusion: Osseointegration is an effective concept for patients after transfemoral amputation who have complaints from the stump and skin problems. Implantation of an ILP improves their function and quality of life.

See pages 91 - 132 for financial disclosure information.

Multiple Orthopaedic Procedures in the Initial Surgical Setting: When Do the Benefits Outweigh the Risks in Patients With Multiple System Trauma?

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Purpose: The objective of this study is to compare the risk of performing orthopaedic procedures in the same setting as other procedures, with the risk of performing an orthopaedic procedure alone, in patients with unstable fractures and multiple system injury. We hypothesized that in resuscitated patients the complication rates would be no different, and that length of hospital stay would be shorter in patients undergoing multiple procedures.

Methods: Patients with high-energy, mechanically unstable fractures of the femur, pelvis, acetabulum, and spine and ISS >16 were prospectively identified over 30 months at a Level I trauma center. A standard protocol for resuscitation was followed to recommend definitive fixation of these fractures once a patient was hemodynamically stable and acidosis had improved to lactate <4.0 mmol/L, pH ≥7.25, or base excess (BE) ≥–5.5 mmol/L. Patient demographic, physiological, and laboratory data were collected, and musculoskeletal and other system injuries and treatment provided were recorded. Surgical duration, fluid, and blood product administration were included. Complications were adjudicated, including pneumonia, ARDS (acute respiratory distress syndrome, infections, DVT (deep vein thrombosis), PE (pulmontary embolism), sepsis, multiple organ failure, and death.

Results: 370 patients were included with fractures of the femur (n = 166), pelvis (n = 70), acetabulum (n = 57), and spine (n = 108). 147 (39.7%) underwent multiple procedures in the initial surgical setting, including definitive stabilization of the aforementioned fractures. Multiple procedure patients had significantly greater ISS (29.4 ± 12.3 vd 24.6 ± 10.2, *P* <0.01), more transfusions (8.86 ± 13.5 U vs 3.55 ± 5.7 U, *P* <0.01), greater estimated blood loss (773 ± 1370 mL vs 443 ± 555 mL, *P* <0.01), and longer surgical duration (4:22 ± 2:07 vs 2:41 ± 1:39, *P* <0.01). In spite of these differences, once adequate resuscitation was provided, no significant differences between groups with multiple versus single procedures were found in pulmonary complications (10.2% vs 14.8%, *P* = 0.50), pneumonia (7.48% vs 12.1%, *P* =0.15), infection (7.48% vs 8.52%, *P* = 0.72), sepsis (6.85% vs 5.38%, *P* = 0.56), mortality (3.40% vs 2.69%, *P* = 0.69), or overall complication rate (33.3% vs 30.0%, *P* = 0.50). Contrary to our hypothesis, multiple procedure patients had greater length of stay (12.4 ± 9.3 days vs 10.0 ± 9.0, *P* = 0.018) spending a mean of 1.41 additional days on the floor (5.97 ± 4.0 days vs 4.56 ± 4.3, *P* <0.01), although no more time in the ICU (6.38 ± 8.5 days vs 5.77 ± 9.3, *P* = 0.51).

Conclusion: Prior work has shown benefits of resuscitation in normalizing acidosis associated with severe trauma. A standardized protocol to measure the adequacy of resuscitation and to determine readiness for orthopaedic surgery results in an acceptable risk of complications. Multiple procedures did not increase the frequency of pulmonary or other complications versus patients who had a single procedure, despite greater ISS, more transfusions, and longer surgical duration in the multiple procedure group. Performing multiple procedures in the same setting likely reduces treatment expenses and risk associated with additional

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surgeries on other days. Additional study to characterize these two groups and to minimize risk will be helpful before making broad treatment recommendations.

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Early Appropriate Care: A Protocol to Standardize Resuscitation Assessment and to Expedite Fracture Care Reduces Hospital Stay and Enhances Revenue

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Purpose: Previous study has demonstrated a substantial multiplier effect for professional activity related to care of polytraumatized patients, such that the trauma center collects revenue several times larger than that of the surgical providers. We hypothesized that our trauma service line would have a favorable payer mix within our hospital and would be the beneficiary of a large multiplier effect. We further hypothesized that a standardized protocol for trauma care would enhance revenue by decreasing length of stay, reducing complications, and thus generating a larger percentage of collections for care of a given type of injury.

Methods: Financial records were obtained for patients prospectively treated with a standardized protocol for resuscitation after multiple system trauma. 253 consecutive adult patients with mean age of 40.7 years and mean ISS of 26.0 (all >16) who were treated surgically during 18 months for fractures of the femur, pelvis, or spine were included. The trauma center is a large urban, public hospital, and the physicians are hospital employees. Hospital facility charges and collections and professional charges and collections for the injury inpatient and related outpatient care for 6 months were analyzed. Timing of fracture fixation was defined as early (within 36 hours after injury) or delayed. Complications were recorded and hospital stay was characterized.

Results: Mean facility charges were $142,533 with mean $59,882 in collections (42%). Mean professional charges were $37,612 with mean $6989 in collections (19%). Mean total facility charges were $180,145 with mean $66,871 in collections (37%). The revenue multiplier effect was $59,882/$6989 (8.57), indicating a hospital collection of $8.57 for every dollar of professional collections, less than half of which went to orthopaedic surgeons. The trauma payer mix was favorable compared to the hospital with over three times as much Workers' Compensation (BWC) and less than half as much Medicare in the trauma group. Commercial and BWC were the best payers with 58.5% and 59.3% collected, respectively, on facility charges. When fracture care was delayed, mean ICU days increased from 4.5 to 9.4 days, and the total hospital stay increased from 9.4 to 15.3 days. Mean loss of revenue based on actual hospital costs for the increased length of stay alone was $6380 per patient delayed (n = 47). Interestingly, professional collection percentages increased by 4.3% in patients with delayed care, with more total episodes of surgical care on different days, likely due to limited discounting for multiple procedures in the same surgical setting. Complications were associated with the largest treatment expenses: mean $291,846 charges and $101,005 collections (35%). Facility collections decreased by 5% when a complication occurred. In contrast, an uncomplicated course of care was associated with the most favorable total collections: ($54,213/$140,797 = 38.5%) and the shortest mean total stay (8.0 days).

Conclusion: The trauma service line appears favorable in terms of payer mix. Facility collections were nearly 9 times those of the providers. An uncomplicated course of care resulted in the greatest total percent collections. Delays in fracture care were associated

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with more complications and longer hospital stays. Facility collections decreased by 5% when a complication occurred. Furthermore, delayed fracture care significantly increased hospital stay, accounting for ~$300K more in actual hospital costs alone over the course of the study. A standardized protocol to expedite definitive fracture fixation when patients are physiologically optimized appears efficacious in enhancing the profitability of the trauma service line.

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The Effect of Surgical Treatment on Mortality After Acetabular Fracture in the Elderly: A Multicenter Study of 454 Patients

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Purpose: Controversy exists regarding the effect of surgical treatment on mortality after acetabular fracture in elderly patients. Our hypothesis was that surgical treatment would confer a mortality benefit compared to nonsurgical treatment even after adjusting for comorbidities associated with death.

Methods: Institutional trauma databases were searched for all patients age 60 years and older who had been treated for acetabular fractures (62-A, B, C) at 3 academic Level-I trauma centers between 2002 and 2009. Medical records were reviewed to determine demographic characteristics, comorbidities, fracture patterns, dates of treatment, and method of treatment as nonsurgical versus surgical. Surgical treatment was further classified into three groups: traditional open reduction and internal fixation, percutaneous fixation, or acute arthroplasty. Our study sample consisted of 454 patients with a average age of 74 years. Mortality was determined using the social security death index. Kaplan-Meier survival curves were created and Cox proportional hazards models were used to calculate unadjusted and adjusted hazard ratios for covariates of interest.

Results: In contrast to previous smaller studies, the overall mortality was relatively low at 16% at 1 year (95% confidence interval [CI] 13%-19%). Unadjusted survivorship curves suggested higher mortality rates for nonsurgically treated patients (P <0.001); however, the treatment decision for nonsurgical treatment was associated with other factors associated with higher mortality. Our final multivariate model of survival demonstrated no significant difference in hazard of death for nonsurgical treatment (P >0.10), nor for any of the surgical treatment subgroups (P >0.10). As expected we did find a significantly increased hazard for factors such as the Charlson comorbidity index (per point), age (hazard ratio was 1.09 [95% CI 1.06-1.12]) per year of age over 70), and length of stay (per day) (all P <0.05). In addition associated fracture patterns (compared to elementary patterns) significantly increased the hazard of death with a ratio of 1.46 (95% CI 1.07-2.00).

Conclusion: In contrast to the rationale for surgical treatment of hip fractures, the surgical treatment of acetabular fractures does not appear to convey a mortality benefit once comorbidities are taken into account. The reason for this is unknown, but might be related to greater limitations in postoperative weight-bearing status compared to those after hip fracture surgery. Regardless of the cause, it does not appear that surgical treatment of geriatric acetabular fractures can be justified based on mortality benefit alone.

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Acute Total Hip Arthroplasty Versus Open Reduction and Internal Fixation for Acetabular Fractures Involving the Posterior Wall in Patients <65 Years Old: A Matched Cohort Analysis

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Purpose: Acute total hip arthroplasty (THA) has been advocated for acetabular fractures in elderly patients; however, its usage in younger patients with fractures at high risk for reoperation, such as those involving the posterior wall, has rarely been studied. We hypothesized that patients <65 years old who underwent acute THA would have lower rates of reoperation and similar functional outcomes compared those underwent open reduction and internal fixation (ORIF).

Methods: We retrospectively reviewed consecutive patients under the age of 65 with acetabular fractures involving the posterior wall (62A1, 62A2 + posterior wall, 62B1 + posterior wall) treated at a Level I trauma center from 1996 to 2011. Operatively treated patients were grouped by acute THA or ORIF and were matched by fracture pattern and age at a 2:1 ratio within blocks of 5 years. Patients without a minimum of 1-year follow-up were excluded. The modified Oxford Hip Score* was used to assess functional outcome. Rates of reoperation and referral for THA were recorded. A P <0.05 was considered significant.

Results: 16 THA patients and 32 ORIF patients were evaluated at an average follow-up of 6.2 years (range, 1-15.2) with an average age of 56.4 versus 54.3 years (P = 0.163). There was no difference in the proportion of high-energy mechanisms of injury (100% vs 75%, P = 0.154) or ISS (11.7 vs 13.5, P p = 0.525). There were significant differences in the rates of marginal impaction (94% THA vs 41% ORIF, p < 0.001), full thickness cartilage injury to the femoral head (69% THA v 19% ORIF, P = 0.001), and involvement of the weight-bearing dome (44% THA vs 13% ORIF, P = 0.027). At last follow-up, 12 hips (37.5%) in the ORIF group had undergone THA or been referred for THA; 75% of these occurred within 1 year, and 83% were within 2 years. This was compared to 2 revisions (12.5%, P = 0.312) in the THA group: one loose cup at 2 months and one infection at 14 years. There was no difference in surgical time, blood loss, or the number of postoperative complications. The average time to full weight bearing was 98 days in the ORIF group compared to 71 days in the acute THA group (P = 0.045). The average Oxford Hip Score in the acute THA group was 44 compared to 40 in the ORIF group (P = 0.048) and there was no difference in the number of good-excellent results (93% vs 85%, P = 0.636).

Conclusion: Both ORIF and acute THA for high-energy acetabular fractures involving the posterior wall in middle-aged patients can provide excellent results. Acute THA may be more appropriate for those with femoral head involvement, articular comminution, or marginal impaction. Acute THA patients had better functional scores and earlier weight bearing. The indications for and utility of acute THA in this group warrant further investigation.

*Oxford Hip Score: range 0-48; >41 = excellent, 34-41 = good, 27-33 = fair, <27 = poor.

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Patient-Reported Health After Surgically Treated Displaced Sacral Fractures: A 10-Year Follow-up

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Purpose: Displaced sacral fractures are associated with considerable morbidity. The aim of this study was to assess the long-term patient-reported health after surgically treated displaced sacral fractures, its association with clinical outcomes, and changes over time

Methods: Between 1996 and 2001, 32 consecutive patients with surgically treated displaced sacral fractures were included in a 1-year clinical outcome study, the results of which have been previously published. In the present study, 28 of these patients were available for follow-up, mean 10.7 years (range, 8.1-13.4) postinjury. Collected data included patient-reported health with Short Form-36 (SF-36), pain (visual analog scale), neurologic deficits in the lower extremities, and urinary, bowel, and sexual function. The SF-36 scores were compared to the Norwegian general population scores (NBS) and the previously published 1-year scores.

Results: At 10 years, the SF-36 scores were significantly lower than the NBS in all subscales. No significant changes were found between 1- and 10-year scores. We found significant correlations between pain and poor Physical Functioning (P = 0.05), Role Physical (P = 0.01), Bodily Pain (BP) (P = 0.003), General Health (P = 0.007), and Role Emotional (RE) (P = 0.006). Sexual dysfunction was significantly correlated with poor Social Functioning (P = 0.013) and RE (P = 0.04), and bowel dysfunctions with BP (P = 0.02) and poor RE (P = 0.03). No correlations were found between SF-36 and urinary dysfunction or neurologic deficits in the lower extremities.

Conclusion: Patients with displaced sacral fractures reported poor health at 10 years, compared to the general population, with no significant improvement between 1 and 10 years. Poor self-reported health was associated with pain and sexual and bowel dysfunctions. The strongest association was found between pain and patient-reported health, suggesting a special attention to pain treatment, in order to improve quality of life in these patients.

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•Recombinant Human Morphogenetic Protein-2 (rhBMP-2) Versus Iliac Crest Autograft to Treat Tibia Nonunion: A Retrospective Multicenter Study

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Background/Purpose: There is no consensus opinion on the use of recombinant human morphogenetic protein (rhBMP) in the treatment of tibia fracture nonunions. Avoidance of complications associated with iliac crest autograft harvesting has led to a high level of off-label rhBMP-2 use to treat fracture nonunions. Complications with the use of off-label rhBMP-2 in cervical fusion have raised interest in the off-label use of rhBMP-2 in orthopaedic trauma. The purpose of this study was to retrospectively examine the union rate and adverse events associated with the use of rhBMP-2 compared to iliac crest autograft for the treatment of tibia nonunions.

Methods: We retrospectively reviewed the management of all consecutive tibia nonunions in patients who were treated with either rhBMP-2 (n = 33) or iliac crest autograft (n = 132) between January 1, 2002 and December 31, 2008 at five Level I orthopaedic trauma centers. Clinical records and radiographs were reviewed to determine the rate of fracture union and incidence of adverse events.

Results: The two intervention groups were statistically similar. The healing rates were 84.9% and 74.2% for the rhBMP-2 and iliac crest autograft groups respectively ($P = 0.20$). Bivariate logistic regression analysis comparing rhBMP-2 and iliac crest autograft with fracture union revealed an odds ratio (OR) of 1.94 favoring rhBMP-2, but this was not statistically significant (95% confidence interval [CI]: 0.69-5.43, $P = 0.21$). While controlling for age, gender, prior infection, and intramedullary fixation, the OR comparing rhBMP-2 and iliac crest was 2.01 (95% CI: 0.70-5.82, $P = 0.20$). The length of stay was statistically significant favoring the rhBMP-2 group (2.7 days vs 3.6 days, $P = 0.005$).

Conclusion: In a retrospective, multicenter study, rhBMP-2 appears to have similar union rates compared to iliac crest autograft in the treatment of atrophic or oligotrophic tibia nonunions. Our data revealed a statistically significant shorter length of stay for patients treated with rhBMP-2 compared to iliac crest autograft.

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The Reamer Irrigator Aspirator (RIA) as a Device for Harvesting Bone Graft Compared With Iliac Crest Bone Graft: Union Rates and Complications

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Purpose: This study was performed to determine if patient outcomes after reamer irrigator aspirator (RIA)–harvested bone grafting are inferior, equivalent, or better than outcomes for patients treated with the current gold standard, either anterior or posterior iliac crest graft (ICG).

Methods: 133 patients with nonunion or posttraumatic segmental bone defect requiring surgical intervention were prospectively randomized to receive ICG or RIA autograft. Supplemental internal fixation was performed per surgeon preference. Surgical data included amount of graft, time of harvest, and associated surgical costs. The Short Musculoskeletal Functional Assessment (SMFA) and the visual analog scale (VAS) were used to document baseline and postoperative function and pain. Clinical and radiographic union was the defined end point; patients developing infection or nonunion requiring reoperation on the grafted extremity were considered to have failed the index treatment.

Results: 113 of 133 enrolled patients were followed until union and included in the final analysis. Intraoperative data showed anterior ICG to yield 20.7 ± 12.8 cc (range, 5-60) of autograft with an average harvest time of 33.2 ± 16.2 minutes; posterior ICG yielded 36.1 ± 21.3 cc (range, 20-100) of autograft in 40.6 ± 11.2 minutes; and RIA yielded 37.7 ± 12.9 cc (range, 5-90) in 29.4 ± 15.1 minutes. Anterior ICG produced significantly less bone graft than either RIA or posterior ICG (P <0.001). The RIA harvest took a significantly shorter duration of operative time compared to posterior ICG (P = 0.005). Anterior ICG did not differ in duration of harvest from either RIA or posterior ICG. At $738, the RIA setup was considerably more expensive than the $100 cost of a bone graft tray; however, when compared to posterior ICG, the longer operative time required for a posterior harvest came at an additional incremental cost of $1780, making RIA the less expensive option. Patients were followed for an average of 56.9 ± 42.1 (range, 11-250) weeks. 49 of 57 patients (86.0%) who received ICG united in an average of 22.5 ± 13.2 weeks; 46 of 56 patients (82.1%) who received RIA healed in an average of 25.8 ± 17.0 weeks. Union rates and time to union were equivalent comparing both procedures. There was no difference in complications requiring reoperation for persistent nonunion or infection. Postoperative follow-up showed that RIA patients had significantly lower donor site pain scores throughout follow-up. There was no difference in donor site complications.

Conclusion: When compared to autograft obtained from the iliac crest, autograft harvested using the RIA technique achieves similar union rates with significantly less donor site pain. RIA also yields a greater volume of graft compared to anterior ICG and has a shorter harvest time compared to posterior ICG. For larger-volume harvests, cost analysis favors using RIA.

Funding: This study was partially funded by the Southeast Fracture Consortium. RIA setups were provided by Synthes for the study free of charge.

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Dynamizations and Exchange Nailing: Success Rates and Indications

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Background/Purpose: Tibial nailing is an accepted and successful treatment for tibia fractures; however, the secondary intervention rate for tibia fractures in large trials has been reported to be >15%. When nailed fractures go on to delayed or nonunion, exchange nailing and dynamization are two common secondary interventions. There are no data comparing union rates in like patients and little data available at all regarding dynamization. The purpose of this study is to report on the timing, indications, and success rates of dynamization and exchange nailing in a multicenter study and to compare these two techniques where appropriate.

Methods: The records and radiographs of 183 tibia fractures in multiple centers that had dynamization or exchange nailing for delayed/nonunion were reviewed. Delayed/nonunion was defined as at least 3 months postsurgery with no progression. Demographic data, fracture type, cortical contact/gap, timing of and success rates of the secondary intervention, and RUST (Radiographic Union Score for Tibial fractures) scores at intervention and follow-up were recorded. Success was defined as obtaining union while nonunion or additional intervention defined failure. Two-tailed *t* tests and Fisher exact or χ^2 with *P* set at <0.05 for significance were used as indicated.

Results: A total of 183 tibia fractures underwent dynamization (92) or exchange nailing (91). The average age was 39 years (range, 16-81). There were 141 men and 42 women. Mechanisms of injury were motor vehicle accident (MVA) (53), motorcycle accident (MCA) (47), pedestrian struck (26), falls (28), direct blow (16), and other (13). There were 112 open (50% grade III) and 71 closed fractures in the proximal (21%), midshaft (30%), or distal (49%) tibia. No statistical differences were found between the dynamization and exchange nailing groups with respect to demographics or fracture characteristics, although a gap or bone defect was more common in the exchange group (20% vs 34%, $P = 0.06$). The success rates of the interventions were not different for exchange nails ($P = 0.3$) or dynamizations ($P = 0.75$) performed early versus after 6 months nor were the RUST scores for successful versus failed procedures ($P = 0.96$ and 0.43) allowing for pooling of the data. 14 patients were lost or are currently in follow-up, leaving 169 fractures followed to union or failure.

See pages 91 - 132 for financial disclosure information.

Table 1 details the primary results:

Table 1: Results

Intervention	N	Median Days to Surgery (days)	RUST Preop	Union n (%)	Median Time to Union (mos)	RUST Union
Dynamization	83	166	7.1	70 (84%)	10.8	10.0
Exchange	86	194	6.7	79 (92%)	13.2	10.3
P value	NA	NA	0.06	0.16	NA	0.4

The RUST scores at the time of intervention were not different for successful or failed dynamizations (7.02 vs 7.0, $P = 0.96$) or exchanges (6.5 vs 7.2, $P = 0.43$). Likewise, the time to successful versus failed dynamization (170 vs 169 days, $P = 0.97$) or exchange nailing (231 vs 191 days, $P = 0.33$) was not different. However, no cortical contact or a gap was a statistically negative factor for both exchange nails ($P = 0.09$) and dynamizations ($P = 0.06$). When combined, the success in the face of a gap was 78% versus 92% when no gap was present ($P = 0.03$).

Conclusion: Prior literature has few reports of the success rates of distant site interventions for tibial nonunions. The indications for dynamization and exchange were similar with RUST scores of 6.7 versus 7.1 and the median time to intervention close to 6 months in both groups. Having no cortical contact or gap favored having an exchange nail performed, and was a negative prognostic factor for both procedures. The current study demonstrates high rates of union for both dynamization and exchange nailing making both viable options.

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PRESIDENT'S MESSAGE
Andrew H. Schmidt, MD
"Standardization and Systems: Steps We Must Take (Together)"

NOTES

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CASE PRESENTATIONS

Orthopaedic Trauma Coding
Moderator: *J. Scott Broderick, MD*
Faculty: *William R. Creevy, MD* and *M. Bradford Henley, MD*

The Challenging Hip Fracture: Pearls and Pitfalls
Moderator: *Amer J. Mirza, MD*
Faculty: *Darin Freiss, MD; Erik Kubiak, MD* and *Edward A. Perez, MD*

Proximal Humerus ORIF – Advances in Fixation and Augmentation
Moderator: *Clifford B. Jones, MD*
Faculty: *Michael J. Gardner, MD* and *Samir Mehta, MD*

2 Minutes / 2 Slides: Ankle Injuries Technical Tips and Tricks
Moderator: *Pierre Guy, MD, MBA*
Faculty: *Kenneth A. Egol, MD; David W. Sanders, MD; Paul Tornetta, III, MD* and *Timothy O. White, MD*

Distal Humerus Fractures: Tips and Tricks
Moderator: *Utku Kandemir, MD*
Faculty: *John T. Gorczyca, MD; Michael D. McKee, MD* and *Milan K. Sen, MD*

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SKILLS LABS

Fixation of Clavicle Fractures *(#SL1)*
Lab Leader: *Gregory M. Osgood, MD*
Faculty: *Daren P. Forward, MD; Erik A. Hasenboehler, MD; Joseph E. Strauss, DO, CDR* and *David B. Weiss, MD*

ORIF Distal Tibia and Fibula Fractures *(#SL2)*
Lab Leader: *Matt L. Graves, MD*
Faculty: *David P. Barei, MD, FRCSC; Patrick F. Bergin, MD; Jason W. Nascone, MD; Timothy G. Weber, MD* and *Bradley J. Yoo, MD*

NOTES

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Association Between Type of Surgery and Perioperative Acute Myocardial Infarction in Elderly Hip Fracture Patients

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Background/Purpose: Recent noncardiac surgical research suggests that perioperative myocardial infarction (MI) is becoming a dominant complication after noncardiac surgery. However, the incidence of perioperative MI in surgically treated hip fracture patients is unknown. Moreover, the impact of the type of surgery on MI risk is unknown.The aims of this study were to determine the incidence of inpatient MI in surgically treated low-energy hip fracture patients, and whether the odds of MI differed by the type of surgery (internal fixation [IF], hemiarthroplasty [HA], or total hip arthroplasty [THA]) after controlling for other factors. We hypothesized that MI risk would be highest after arthroplasty.

Methods: We used a retrospective cohort of low-energy, surgically treated hip fracture patients (ICD-9 820.x, OA/OTA 31-A, 31-B) age 65 years or older from the 2000-2009 Healthcare Cost and Utilization Project (HCUP) Nationwide Inpatient Sample. Patients with cancer, revisions, infection, or high-energy trauma were excluded. The primary outcome was acute MI; the secondary outcome was mortality. Multivariate logistic regression modeled the association between the type of surgery (IF, HA, THA) and MI, controlling for age, sex, type of fracture, and modified Charlson score without acute MI. Incidence estimates (inpatient MI and MI-associated mortality) and adjusted odds ratios (OR) from SAS survey procedures are reported.

Results: 2,275,944 discharges met inclusion criteria. The mean patient age was 83 years and most patients were female (75.6%). IF was used in 63.4% of patients; 34.0% received HA and 2.6% received THA. Nearly half of the fractures were intertrochanteric or subtrochanteric (50.9% combined) and 96.5% of these were treated with IF. Femoral neck (28.9%) and unspecified femoral neck fractures (20.2%; ICD-9 820.8, 820.9) comprised the remaining hip fractures of which 66.1% received HA and 4.8% THA. Perioperative acute MI occurred in 2.2% of patients overall. MI differed by procedure and was highest after HA (2.5%) and lowest after IF (2.0%). Multivariate analysis showed a similar pattern by procedure. The odds of acute MI were higher after HA (OR 1.46; 95%confidence interval [CI] 1.38, 1.56) and THA (OR 1.27; 95% CI 1.10, 1.46) compared with IF, after controlling for other factors. Overall, inpatient mortality after acute MI was eight times that of patients without MI (17.4% vs 2.2%) and MI-associated mortality was highest after THA (18.2%).

Conclusion: Arthroplasty was associated with higher odds of MI and higher MI-associated

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mortality than internal fixation in older hip fracture patients. Acute MI is a deadly perioperative condition after hip fracture. When considering arthroplasty for treatment of a hip fracture, the surgeon must weigh the additional MI risk and associated mortality of this procedure versus internal fixation. Routine screening for MI could improve survival since early intervention after MI improves outcomes.

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Effect of Vitamin K on Surgical Timing After Hip Fracture in Patients on Warfarin

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Purpose: This study was undertaken to characterize treatment patterns for patients sustaining a proximal femur fracture while taking warfarin.

Methods: All patients undergoing treatment of a proximal femur fracture over a 3-year period were identified using CPT codes from a surgical database at a Level I trauma center. 438 patients were identified and their charts reviewed. Patients with an international normalized ratio (INR) ≥1.5 at admission who were taking warfarin were included in the study. Treatment of the elevated INR was classified as either vitamin K administration or expectant management. Vitamin K administration and timing were recorded. Vitamin K administration was classified as immediate if received in the emergency department within 4 hours and delayed if given later. INR values throughout hospitalization and timing of surgery were recorded. INR values at presentation were compared using an independent samples *t* test. An analysis of variance (ANOVA) test was used to compare impact of treatment on INR over the first 24 hours, as well as on timing to surgery. Tukey HSD (honestly significant difference) was used for post hoc analysis. Fisher exact test was used to compare the percentage of patients able to go to surgery by the day after admission for each group.

Results: Of 438 patients, 40 (9.1%) had an elevated INR due to treatment with warfarin. There were 15 men and 25 women with an average age of 81 years (range, 34-100). Indications for taking warfarin were: atrial fibrillation (27), history of thromboembolic disease (8), both atrial fibrillation with history of thromboembolic disease (3), and prosthetic valve replacement (2). INR on admission averaged 2.2 (range, 1.5-4.1) for those managed expectantly and 2.8 (range, 1.6-7.4) for those treated with vitamin K ($P = 0.06$). 28 patients were treated with vitamin K and 12 patients were managed expectantly. Of patients treated with vitamin K, the medication was administered an average of 6.7 hours after the return of the initial INR laboratory value (range, 1-20 hours). Those who received immediate vitamin K (within 4 hours) had an average correction of 1.3 in their INR within 24 hours while those who had delayed administration had a correction of 0.3 and those who did not receive vitamin K had an average increase of 0.2 ($P = 0.04$). Post hoc testing showed significance was due to difference between the immediate vitamin K and expectant management groups ($P < 0.01$). When vitamin K was given immediately, 75% of patients had surgery by the day after admission. When managed expectantly, 58% went to surgery by this time and when vitamin K treatment was delayed, 31% went to surgery by the day after admission ($P = 0.06$). No patient in any group had thromboembolic complication from correction of coagulopathy.

Conclusion: Treatment of the coagulopathic patient requiring urgent surgery is controversial and complicated. Patients who receive vitamin K early have quicker correction of INR. Patients who did not receive vitamin K showed no significant improvement in INR for 24 hours (average <u>increase</u> of 0.2) despite the fact that the INR was significantly lower. Most patient who received early vitamin K got surgery within 24 hours.

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PAPER ABSTRACTS

Healing Time and Complications in Surgically Treated Atypical Femur Fractures Associated With Bisphosphonate Use: A Multicenter Series

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Background/Purpose: Atypical femur fractures associated with bisphosphonate use have been reported to have high nonunion rates and delayed healing. However, published trials have had small patient numbers limiting their conclusions. The purpose of this study is to characterize the demographics, rate of union, healing time, and complications of a large series of surgically treated atypical bisphosphonate femur fractures as well as the natural history of the contralateral femur.

Methods: All bisphosphonate-related fractures as defined by the ASBMR (American Society for Bone and Mineral Research) task force document from 15 centers were reviewed in detail. To be included, patients had to have been treated with bisphosphonates for at least 12 months. Fractures had to be operatively treated and followed for at least 6 months or to union or revision. Average follow-up was 16 months. Data collected included demographics, medication history, prodromal history, injury and surgery characteristics, complications, revision surgery, and time to union. Information about the contralateral limb, when available, was recorded including prodromal symptoms, radiographic signs of stress, and subsequent fracture.

Results: There were 196 patients, 178 women and 18 men, average age 73 years (range, 32-96) and average BMI (body mass index) 27.5; 77% had at least one additional medical risk factor including diabetes, rheumatoid arthritis, thyroid disease, or smoking. 20% of patients had a prior history of fragility fracture, 34% had prodromal pain in the extremity, and 19 of 135 that had clear documentation had pain in the contralateral extremity. 98% percent

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were ambulatory, 28% with an assistive device, and 85% were living independently prior to the fracture. Patients averaged 79 (range, 12-192) months of bisphosphonate use prior to injury and 51% of patients discontinued bisphosphonates at the time of surgery. 27% had radiographic changes suggesting stress reaction prior to injury and 10% of fractures were periprosthetic. Surgical fixation was with cephalomedullary nail (50%), antegrade nail (37%), retrograde nail (5%), or plate (8%). Complications included pneumonia (4), death (4), pulmonary embolism (3), superficial or deep wound infection (7), hematoma (2), and screw removal (3). 18 patients (9%) underwent revision surgery at an average of 13 months after the initial procedure, most commonly with a cephalomedullary nail. Excluding those who required revision surgery, the average union time was 5.2 months (6.4 for plates and 5.1 for nails) for those whose time to union was clearly discernable based on visit intervals. 22% of patients took >6 months to heal. For the patients who had revision surgery, union occurred at an average of 10 months after secondary intervention, although 5 were lost to follow-up. Continuation or discontinuation of bisphosphonates did not have an effect on time to union ($P = 0.85$) or the need for revision surgery ($P = 0.51$). After fracture fixation patients achieved full ambulation at an average of 4 months, and 92% were living in their homes at the time of final follow-up (25% with help). 9% had a non-femur fragility fracture during follow-up. 20% of patients sustained a contralateral femur fracture, 23 months on average after their index procedure; 45% of these had discontinued bisphosphonate treatment at the time of their index procedure. Of those with information available, 23% had prodromal pain and 35% had a stress reaction on radiography prior to their contralateral fracture.

Conclusion: In this large, multicenter series, atypical bisphosphonate femur fractures occurred primarily in an independently living and ambulatory population. Surgery had a 9% failure rate requiring revision surgery and 22% took greater than 6 months to heal. 20% of patients developed contralateral femur fractures within 2 years, underscoring the need to evaluate the contralateral extremity for stress reactions. Most importantly, 92% were living at home and only 8% were in facilities at final follow-up. This patient population is distinctly different than osteoporotic hip fracture patients and had only a 2% mortality rate at average 16 months.

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Rehospitalization After Surgically Treated Hip Fractures: Targets for Intervention

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Background/Purpose: Unintended 30-day rehospitalization cost Medicare $17.4 billion in 2004. The U.S. Department of Health and Human Services declared a goal of decreased rehospitalization rate by 20% in 2013. Rehospitalization rate after hip fracture is 18%, according to a Medicare claims review. This study of elderly hip fracture patients aims to identify risk factors for rehospitalization, directing future intervention and study.

Methods: Patients over 60 years of age with a femoral neck or intertrochanteric femur fracture treated surgically at 10 hospitals from May 2008 to November 2011 enrolled in a prospective cohort study. Subjects with cognitive impairment (Short Blessed Scale <14) that persisted for 1 week after surgical treatment were excluded. Scheduled periodic follow-up over 1 year was conducted by trained interviewers. At 1, 2, 4, 8, and 12-week interviews, the enrollees and their caregivers were questioned regarding new diagnoses, medications, and hospitalizations. Reasons for rehospitalization came from self or family reporting. 609 patients underwent screening for enrollment. 138 patients were excluded and 70 patients electively withdrew prior to completion of the study, leaving 471 subjects.

Results: Of 471 patients who participated in the study, 33 (7.0%) patients died during the 1-year study period. 388 subjects (82.4%) provided complete 12-week data. Of these 388 patients, 42 (10.8%) and 78 (20.1%) were rehospitalized at 30 and 90 days, respectively. Additionally, 5 patients were rehospitalized twice in the first 30 days. Categorized results show that hip-related complications (pain, dislocation, need for revision surgery) were the most common reasons for rehospitalization, making up 17% of the 30-day and 16% of the 90-day rehospitalizations. Gastrointestinal (GI) complications, including infection and bleeding, were the second most common reasons for rehospitalization at both 30 (15%) and 90 days (13%). Thromboembolism (11% and 12%) was also a common reason for return to the hospital.

Conclusion: 30-day rehospitalization (10.8%) and 1-year mortality (7.0%) rates in a cohort study of cognitively intact patients were lower than historical rates. Mechanical hip complications and hip pain were the most common reasons to be rehospitalized in the first 30 and 90 days after treatment of hip fracture. The proportion of hip complications did not change between the 30-day and 90-day time periods. Potential targets for intervention to decrease rehospitalization include orthopaedic surgical treatment, prevention of GI and pulmonary infection, and thromboembolic prevention and streamlined management.

See pages 91 - 132 for financial disclosure information.

Can an Evidence-Based Treatment Algorithm for Intertrochanteric Hip Fractures Maintain Quality at a Reduced Cost?

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Purpose: This study was undertaken to compare the treatment costs of intertrochanteric hip fractures before and after the implementation of an evidenced-based treatment algorithm using the OTA classification system.

Methods: In March 2012 a classification-based treatment algorithm for intertrochanteric hip fractures (OTA 31-A) was implemented across our academic orthopaedic surgery department that included specified implant usage for specific fracture patterns. 102 consecutive patients presenting with intertrochanteric hip fractures were followed prospectively (post-algorithm group). Another 117 consecutive patients who had been treated immediately prior to the implementation of the algorithm were identified retrospectively as a control group (pre-algorithm group). OTA classification of fracture, type of hardware implanted (sliding hip screw [SHS], short cephalomedullary nail [CMN], long cephalomedullary nail [CMNL]) and implant cost as well as treatment-related complications were recorded. Comparisons were made between the two groups. The algorithm was retrospectively applied to the pre-algorithm group to determine the potential savings that would have resulted if the protocol was followed with these cases.

Results: The demographics of the two cohorts did not differ and the percentages of fracture patterns treated were similar. Prior to implementation of the algorithm 41.9% of patients were treated with a different implant than what would have been prescribed by the algorithm. Following institution of the protocol, 89% surgeon compliance was obtained. The total implant cost prior to algorithm implementation was $357,457 (mean: $3,055, standard deviation [SD]: $1311): 27% SHS, 21% CMN, and 52% CMNL; compared to $255,120 (mean: $2,501, SD: $1272) post-algorithm consisting of 40% SHS, 34% CMN, and 26% CMNL. Of note patients who were treated with the algorithm had fewer complications (33% pre-algorithm vs 22.5% post-algorithm) ($P = 0.088$). The algorithm was applied retrospectively to the pre-algorithm group to determine the implants that should have been used (40% SHS, 39% CMN, 21% CMNL—similar to the distribution post-algorithm). Had the algorithm been used with the pre-algorithm cases, a total cost of $284,500 (mean: $2454.38, SD: $1230.12) could have been obtained and $70,295 potentially saved. The average cost savings per case would have been approximately $601.

Conclusion: The implementation of an evidence-based intertrochanteric fracture classification/implant selection algorithm effectively reduced costs in our institution while maintaining quality of care with a lower rate of complications and readmissions. These cost savings are independent of any special pricing arrangements or institutional discounts that can also be arranged. This strategy has potential implications in physician gainsharing programs.

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Δ Intramedullary Versus Extramedullary Fixation of Unstable Intertrochanteric Hip Fractures: A Prospective Randomized Control Study

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Canadian Orthopaedic Trauma Society (COTS);
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Purpose: This study was designed to evaluate the clinical and radiological results of patients with unstable intertrochanteric hip fractures stabilized with an extramedullary device versus an intramedullary (IM) device. The hypothesis is that there would be no significant difference in clinical or radiological outcomes between the two groups.

Methods: 205 patients with unstable (AO-A2) intertrochanteric fractures were enrolled in the study and randomly assigned to receive a DHS or an IM device. The patients were followed for 12 months. Their function was assessed using the Lower Extremity Measure (LEM), a 2-minute walk test, the Timed Up and Go (TUG) test, the functional independent measure (FIM), and a Trendelenburg test. The radiographs were evaluated for tip-to-apex distance (TAD), femoral neck shortening, and heterotopic ossification. Patients were evaluated initially, at 6 weeks, and 3, 6, and 12 months postoperatively.

Results: 168 patients completed the 12-month follow-up visit. Two DHS implants and one TFN failed and required revision to hip arthroplasties. No significant differences were found in the primary outcome, the LEM scores, at any of the follow-up time points. Furthermore, there was no difference in any of the other clinical parameters between the two groups. Radiographically, the intramedullary devices led to less femoral neck shortening and the DHS led to less Brooker stage 1 and 2 heterotopic ossification.

Conclusion: While the use of intramedullary devices radiographically leads to less femoral neck shortening when compared to the DHS for the treatment of unstable intertrochanteric fractures, this does not translate into a better clinical outcome.

Δ OTA Grant

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Is Immediate Weight Bearing Safe for Periprosthetic Distal Femur Fractures Treated With Locked Plating?

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Background/Purpose: Periprosthetic distal femur fractures (PPDFx) associated with total knee replacement are increasing in incidence. In a previous study we showed that these patients had higher mortality and morbidity, if they were not mobilized quickly. Similar to hip fracture patients, early mobilization, facilitated by weight bearing as tolerated on postoperative day 1, resulted in improved outcome and 1-year survivorship. We hypothesized that treating PPDFx with minimally invasive locked plating, incorporating the described principles of effective bridge plating, and permitting immediate full weight bearing as tolerated would result in few hardware failures and a low rate of complications.

Methods: This was a prospective cohort study of all PPDFx with stable prostheses treated by two fellowship trained orthopaedic traumatologists at a Level I trauma center. Patients were treated by a prospective protocol including admission and evaluation to a hospitalist service from the emergency department, surgery within 24 hours, standardized DVT (deep vein thrombosis) prophylaxis initiated prior to surgery, minimally invasive locked plating, postoperative weight bearing as tolerated, and standardized follow-up for 1 year. Pertinent data collection included demographics, time to surgery, blood loss, length of surgery, perioperative complications, length of stay, disposition status, time to full weight bearing , time to healing, and delayed complications including, nonunion, hardware failure, infection, and symptomatic malunion.

Results: 44 fractures were treated in 42 patients. 72% were female. Mean age was 74. 41 fractures (93%) healed within 20 weeks (mean 16 weeks). There were 2 hardware failures, 1 deep infection, 1 nonunion, and 2 patients with symptomatic malunion. There were 8 symptomatic DVTs (19%) and 1 pulmonary embolism, despite consistent anticoagulation. One patient died within 12 months of injury (2.3%). 31 patients (74%) by one year had returned to their preinjury ambulation status. The hardware failure patients had identifiable technical errors, notably short plates compared to the fracture length.

Conclusion: Locked plating for PPDFx as part of a standardized approach to geriatric fracture management, which includes early surgery and immediate weight bearing, is safe and effective. We found a low morbidity and mortality rate with this approach. Hardware failure can likely be avoided by ensuring appropriate plate length and adequate screw fixation to comply with fixation principles in osteopenic bone. We found no complications related to preoperative DVT prophylaxis. Despite following national guidelines, the most common complication was symptomatic DVT. These results represent a significant overall improvement compared to historical treatments and are likely due to overall better care due to standardized geriatric fracture management as well as technical advances in fracture fixation. We recommend fixating periprosthetic distal femur fractures with locked plates and encouraging immediate weight bearing.

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GUEST NATION – CHINA

Best International Forum Paper: TBD

Guest Nation Presentation
Prof. Wang Manyi, MD – Chinese Orthopaedic Association
"International Comparison of Orthopaedic Post-Graduate Training: China"

NOTES

See pages 91 - 132 for financial disclosure information.

JOHN BORDER MEMORIAL LECTURE

Skeletal Trauma: Global Conundrum

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NOTES

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MINI SYMPOSIA

How to Use the OTA Case Database at Your Institution
Moderator: *Julie Agel, ATC*

Femoral Neck Fractures in Young Adults: Why Are We Not "Fixing" These Better?
Moderator: *Cory A. Collinge, MD*
Faculty: *Michael T. Archdeacon, MD; Frank Liporace, MD* and *Bradley R. Merk, MD*

Traumatic Limb Injuries Requiring Amputation:
A Multidisciplinary Approach Using the Osteomyoplastic (Ertl) Technique
Moderator: *William J. Ertl, MD*
Faculty: *Jonathan D. Day, CPO; Carol P. Dionne, PT, DPT, PhD, OCS;*
Janos P. Ertl, MD and *James R. Ficke, MD*

NOTES

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Δ A Prospective Randomized Trial Investigating the Effect of the Reamer-Irrigator-Aspirator (RIA) on the Volume of Embolic Load and Respiratory Functions During Intramedullary Nailing of Femoral Shaft Fractures

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PAPER ABSTRACTS

Background/Purpose: Reamed, statically locked intramedullary nailing of femoral shaft fractures is associated with a high rate of clinical success. However, reaming is associated with the generation of embolic debris from the intramedullary canal that can cause serious pulmonary, neurologic, and systemic sequelae, including death. The Reamer-Irrigator-Aspirator (RIA) device has been introduced to minimize the amount of marrow debris from the femoral canal during the reaming process. However, to our knowledge, there are no definitive clinical data to confirm this theoretical advantage of the RIA. Using a randomized clinical trial, we sought to determine if the use of the RIA resulted in a decreased amount of emboli compared to standard reaming.

Methods: We performed a prospective, multicenter, randomized clinical trial comparing standard intramedullary reaming versus reaming with the RIA device for isolated, closed femoral shaft fractures. A random number generator was used to randomize consecutive patients to one of two treatment groups: (1) statically locked reamed intramedullary nailing using standard reamers (SR), or (2) statically locked reamed intramedullary nailing using the RIA device (RIA). In addition to physiologic monitoring, all patients were monitored intraoperatively with a continuous transesophageal echocardiogram (TEE) in order to determine the quantity of embolic debris generated by the procedure. The TEE was divided into preoperative (PREOP), reduction (RED), guidewire passage (GW), reaming (REAM), nail insertion (NAIL), and postoperative (POSTOP) segments. The TEE recordings were analyzed for duration, size, and severity of emboli by 3 blinded independent observers.

Results: 28 patients were enrolled; 6 were excluded due to technical difficulties with the TEE/recording. 22 patients completed the study (SR 11, RIA 11). There were no demographic differences between the two groups (SR male/female 7/4, RIA 8/3, $P = 0.879$; mean age SR group 39.2 years, RIA group 39.2 years, $P = 0.998$). The ISS and mechanisms of injury were similar between the two groups. We used a standard, previously validated scoring system for the measurement of emboli from the TEE video recordings. There was a high degree of agreement for the measurements between the three reviewers (intraclass correlation coefficient 0.740, substantial agreement). There was no significant difference in emboli (which escalated beginning with the GW phase) between the two groups during the PREOP, RED, GW, or POSTOP segments. There was a modest reduction in total emboli score during the REAM (SR 5.36 vs RIA 4.06, $P < 0.05$) and NAIL segments (SR 5.15 vs RIA 4.18, $P < 0.05$) in favor of the RIA group. We were unable to correlate this reduction with any improvement in physiologic parameters (mean arterial pressure, end tidal CO_2, O_2 saturation, pH, paO_2, $paCO_2$).

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Conclusion: To our knowledge, this is the first clinical study that examines the effect of the RIA device on emboli; it resulted in a modest reduction of embolic debris during the reaming and nail insertion segments of the operative procedure. We were unable to correlate this with any change in physiologic parameters. Further research in this area is warranted to determine if this modest reduction in emboli with the RIA during the REAM and NAIL segments of femoral nailing results in any physiologic improvement and warrants its increased expense.

See pages 91 - 132 for financial disclosure information.

Morbid Obesity Increases the Risk of Systemic Complications in Patients With Femoral Shaft Fractures

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Purpose: Morbid obesity (body mass index [BMI] ≥40) is being encountered with increasing frequency in orthopaedic trauma patients. We sought to investigate the impact of obesity on morbidity and mortality in patients that underwent reamed intramedullary nailing of closed femoral shaft fractures.

Methods: All patients with a closed femoral shaft fracture that were treated with reamed intramedullary nailing over a 5-year period were queried. Clinical data collected included height, weight, BMI, ISS, GCS (Glasgow Coma Scale), Chest AIS (abbreviated injury scale), time to definitive fixation, hospital days, ICU days, ventilator days, and complications (acute respiratory distress syndrome [ARDS], sepsis, pneumonia, pulmonary embolism, and death). Normal weight patients (BMI <25) were compared to morbidly obese patients (BMI ≥40). Odds ratios (ORs) were used to compare risk of complications. BMI was also analyzed as a continuous variable.

Results: 507 patients were treated; 184 (36%) were of normal weight (BMI <25) and 39 (8%) were morbidly obese (BMI ≥40). Patients with morbid obesity were more likely to be older (39.6 vs 29.3 years, $P < 0.0001$) and female (49% vs 27%). Systemic complications occurred in 9 (23.1%) of morbidly obese and 16 (8.7%) of normal weight patients (OR 3.15, $P = 0.013$). When evaluating individual systemic complications between normal weight and morbidly obese patients, the presence of morbid obesity resulted in an increased risk of ARDS (OR 35.38, $P = 0.019$) and sepsis (OR 6.49, $P = 0.0015$). There was a trend for increased risk of pulmonary embolism in morbidly obese patients compared to normal weight patients (OR 5.028, $P = 0.0536$). Overall, morbidly obese patients with a femur fracture had a mortality rate of 10.2%. Morbidly obese polytraumatized patients (ISS >17) with a femur fracture had a mortality rate of 20%. When comparing mortality between normal weight and morbidly obese patients, the presence of morbid obesity resulted in a significantly increased risk of mortality (OR 46.77, $P = 0.01$). BMI, analyzed as a continuous variable, was found to be an independent predictor of ARDS, sepsis, and death.

Conclusion: Morbid obesity conveys a significantly increased risk for systemic complications in patients with closed femoral shaft fractures. Patients and patient families need to need to be counseled regarding the high risk of morbidity and mortality. More research is required to determine which physiologic factors in morbidly obese patients make them more susceptible to complications following intramedullary nailing of femoral shaft fractures.

PAPER ABSTRACTS

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Operative Versus Nonoperative Treatment of Femoral Fractures in Spinal Cord Injury Patients

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Purpose: The purpose of this study was to compare perioperative morbidity and mortality after operative and nonoperative treatment of femoral fractures in a large cohort of patients with and without spinal cord injury (SCI).

Methods: This was a retrospective cohort study in the Veterans Affairs (VA) hospital system comparing femur fracture patients with and without spinal cord injury over a 5-year period (2001-2006). Demographic information, fracture pattern, and morbidity and mortality data were extracted and analyzed.

Results: We identified 396 veterans with femur fractures and SCI during the study period as compared to 13,350 veterans with femur fractures but without SCI. The SCI group was younger (60 vs 74 years) and had more distal fractures compared to the non-SCI group (51% shaft or distal femur vs 7% shaft or distal femur). In the SCI group, 37% of patients had their fractures managed surgically compared to 78% in the non-SCI group. The only significant difference in morbidity between operatively and nonoperatively treated SCI patients was in the development of decubitus ulcers, with the nonoperative group being more frequently affected. There was no difference in mortality between SCI patients treated with and without surgery. In the non-SCI group, mortality was higher in patients managed nonoperatively as were rates of respiratory failure and thromboembolic events. Bleeding complications were more common in non-SCI patients managed surgically.

Conclusion: This study did not find increased rates of morbidity or mortality among SCI patients treated surgically for femur fractures. On the contrary, the only significant difference in adverse events between SCI groups was a higher rate of pressure ulcers in those who did not have surgery. Surgical treatment optimizes nursing care, physical therapy, and patient mobilization, minimizing the risks of prolonged bed-rest and immobilization. When modern surgical techniques are coupled with meticulous and individualized perioperative management, surgery can be safe and effective. Subsequent research should aim to identify patients and fracture patterns that would benefit the most from surgery.

See pages 91 - 132 for financial disclosure information.

Δ Locked Plating Versus Retrograde Nailing for Distal Femur Fractures: A Multicenter Randomized Trial

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Purpose: Distal femur fractures are challenging injuries. Both retrograde nails and locked plates are used for their treatment with good success. Plates are thought to be more stable, but may be more rigid and be more irritating to soft tissues. The purpose of this study was to evaluate the radiographic, functional and physical outcomes of locked plates versus retrograde nails in an IRB-approved randomized controlled trial (RCT).

Methods: All adult patients with A1-3 or C1 distal femur fractures were offered entry into an IRB-approved RCT. If consented, randomization scheme was with permutated blocks for open and closed fractures using a HIPAA-compliant computer-based system. Demographic data, fracture characteristics, surgical variables, and outcomes were assessed.

Results: 156 patients were randomized to locked plate (80) or intramedullary (IM) nail (76). 126 patients were followed (71 men and 55 women, aged 16 to 90 years [average 51]). The average ISS was 12.6 (range, 9-43) and 34 (27%) were open. 34% had simple intra-articular extension. There were no differences in demographic information or injury pattern. Surgical

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time was 125 ± 61 minutes for nails and 124 ± 51 minutes for plates ($P = 0.96$). Malalignment >5° in any plane was present in 22% of nails and 32% of plates ($P = 0.4$), but valgus of >5° accounted for 87% of plate deformities. Valgus >5° was present in 12% of nails and 20% of plates ($P = 0.05$). Walking ability, stair climbing, pain, and use of supports were graded using categorical values. There were no differences at 3, 6, or 12 months between the groups. The average patient could walk 10 blocks, go up and down stairs using a rail, and occasionally used a cane. At 1 year, 16% of plates and 12% of nails lacked at least 5° of extension. A summary of the 1-year results are seen in the table:

1-Year Results

Group	SMFA*	Bother	EQ-Health	EQ-Index	Flexion	Extension	Walking (1 – 6)	Stairs (1 – 5)
Nail	21.5	22.6	79.5	0.78	114 ± 29	6.2 ± 21	2.74	2.3
Plate	27.4	30.8	71	0.68	111 ± 28	3.7 ± 11	2.89	2.66
***P* value**	0.21	0.16	0.08	0.07	0.63	0.57	0.71	0.33

*SMFA = Short Musculoskeletal Function Assessment.

There was significant improvement in all measures at each interval (see example SMFA below)

Complications included 5 pulmonary embolisms/deep vein thromboses and one death. Revision surgery was needed for nonunion or failure in 5% of nails and 8% of plates and hardware removal in 8 of 54 nails (7 screws and 1 nail) and 6 of 60 plates (plate removal) in which this information was available.

Conclusion: Distal femur fractures have significant disability at 1 year. The average patient had an SMFA of 25, bother index of 27, could walk approximately 10 blocks, and climb stairs with the railing. Additionally, 15% had a flexion contracture of >5°. Malalignment was present in 22% of nails and 32% of plates, with plates having a higher rate of valgus malalignment and full implant removal. Overall functional results trended toward better outcomes in nails than plates for all measures, and although with the current numbers this did not reach statistical significance, the score difference was above the minimum clinical relevance for the SMFA (5.5).

See pages 91 - 132 for financial disclosure information.

Distal Locking in Femoral and Tibial Nailing of 265 Patients Without X-Ray Guidance: A Multicenter Study

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PAPER ABSTRACTS

Purpose: This study was undertaken to determine the accuracy and safety of a new distal locking device in femoral and tibial nailing without x-ray guidance.

Methods: This new distal locking technique was used in 265 femoral and tibial patients in 69 institutions by 127 orthopaedic surgeons. Distal locking was performed using a disposable locking device inserted into the nail to create a pilot hole from inside-out of the distal femoral or tibial nail holes. The device drives a cable drill through the distal nail holes, drills from inside-out through the lateral cortex and out of the bone or skin at 90°. Using this pilot hole either from bone or skin as reference, a drilling-back technique using the cable drill wire was developed without x-ray guidance. A sounding test confirmed screw insertion and was double-checked with x-ray after surgery. Assessment of success rate and average time for locking, as well as monitoring for adverse events were conducted.

Results: 99% of patients (263 of 265) were successfully locked using the device without aid of x-ray. The 2 cases with technical problems were locked using other methods. Average time for complete distal locking was 14 minutes. No device-related adverse events were encountered.

Conclusion: Use of this innovative distal locking device was 99% effective on the first attempt. This device is easy to use, saves time, and eliminates radiation exposure to the surgical team and patient. This locking device (DISTALOCK) was approved by the US Food and Drug Administration in 2011.

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A Prospective Randomized Control Trial of Fixation of Intertrochanteric Fractures: Compression Hip Screw Versus Third Generation Long Cephalomedullary Nail

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Purpose: This study evaluates the clinical outcomes of patients with intertrochanteric fractures treated with dynamic hip compression devices versus third generation long cephalomedullary nails. The hypothesis was that there is no difference in failure rate between the two devices.

Methods: This is a prospective, randomized control trial of fixation of intertrochanteric fractures comparing the Intramedullary Hip Screw (IMHS) and Dynamic Hip Screw (DHS) (Smith & Nephew). Between 2007 and 2010, there were 232 patients (68 males, 164 females) randomized into two equal groups at the Princess Alexandra Hospital. Inclusion criteria were: (1) patient age greater than 60 years, (2) patient had sustained an intertrochanteric femoral fracture, and (3) consent was attained for their randomization and inclusion in the trial. Exclusion criteria for this trial were: (1) multitrauma patients, (2) patient age less than 60, (3) subcapital fractures, (4) subtrochanteric fractures, (5) concomitant femoral shaft fracture, and (6) preexisting distal metalware or malunion precluding the use of a long nail. Each patient was followed up at 3 months and 1 year postoperatively. The primary outcome measures were failure of fixation and the need for reoperation. Secondary outcome measures included intraoperative measures (procedure time, operator, tip-to-apex distance), perioperative measures (hemoglobin levels and transfusion requirements), and postoperative functional outcomes.

Results: The mean age of the total group was 79.5 years. Fractures were divided into stable (n = 109) versus unstable fractures (n = 125). Average operative times were 51 minutes for DHS and 72 minutes for IMHS ($P \leq 0.001$). Tip-to-apex distance was independent of type of fracture or level of surgical expertise (consultant versus registrar) ($P \leq 0.0001$). Fixation failures were observed in 7of 116 patients in the DHS group and 3 of 116 in the IMHS group. Of the 7 fixation failures in the DHS group, 3 were in patients' unstable fractures. Of the 3 failures in the IMHS group, 2 were in patients with unstable fractures. There were 7 revisions in total, 4 in the DHS fixation failure group versus 3 in the IMHS fixation failure group. 49% of patients had a drop of hemoglobin postoperatively and required postoperative blood transfusion (43 DHS, 71 IMHS). Unstable fractures with IMHS had the highest rates of transfusion ($P \leq 0.002$). Mortality rate was 21% at 3 months and 26% at 12 months.

Conclusion: This study did not find a significant difference in fixation failures when comparing DHS and IMHS in patients with intertrochanteric fractures. It also found that DHS has a shorter operating time, independent of operator, and that unstable fractures fixed with IMHS have the highest rates of requiring blood transfusion postoperatively.

See pages 91 - 132 for financial disclosure information.

Femoral Neck Shortening Impairs Gait Pattern and Muscle Strength After Internal Fixation of a Femoral Neck Fracture

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Purpose: Knowledge of long-term physical limitations in patients after internal fixation of a femoral neck fracture is limited. The aim of this study was to assess femoral neck shortening and its consequences on gait pattern and muscle strength in femoral neck fracture patients treated with internal fixation.

Methods: Patients were selected from a multicenter randomized controlled trial, in which femoral neck fracture patients aged ≥50 years, who were ambulatory and not demented prefracture, and treated with internal fixation were studied. Patients were included at least 1 year after internal fixation. Exclusion criteria were (1) revision surgery, (2) unable to walk, (3) other limb abnormality expected to influence gait pattern, (4) previous surgery of the contralateral hip, and (5) radiographs inadequate for measurements. Patient characteristics, SF-12 (Short-Form 12), and WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) scores were collected. Femoral neck shortening was measured radiologically and gait parameters were measured using plantar pressure measurement. Maximum isometric forces of the hip muscles were assessed using handheld dynamometry. Differences between the fractured and the contralateral leg were calculated. Patients were divided into three subgroups of patients with increasing level of femoral neck shortening. Univariate and multivariable analyses were performed to determine risk factors for femoral neck shortening and effects of femoral neck shortening.

Results: 76 patients (median age 68 years) were included. The median femoral neck shortening was 1.1 cm. A heel lift to compensate for this shortening was used by 30% of the patients. Patient self-reported functioning was good (median WOMAC score 86.5). Overall, subtle changes in gait pattern as well as a reduced gait velocity (median 1.1 m/sec) and reduced abductor muscle strength (median –20 N) were observed. Age, weight, and Pauwels classification were risk factors for increased femoral neck shortening. Femoral neck shortening decreased gait velocity and seemed to impair gait symmetry and physical functioning.

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Conclusion: Internal fixation of femoral neck fractures resulted in permanent physical limitations, such as femoral neck shortening, subtle changes in gait pattern, reduced gait velocity, and reduced abductor muscle strength. The relatively young and healthy patients in our study seem capable of compensating. Therefore, attention should be paid to femoral neck shortening and proper correction with a heel lift, as inadequate correction may cause physical complaints and influence outcome.

See pages 91 - 132 for financial disclosure information.

Implication of Subgrouping in Valgus Femoral Neck Fractures: Comparison of 31-B1.1 With 31-B1.2 Fracture in OTA Classification

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Purpose: This study aimed to identify the clinical implications of valgus impacted femoral neck fractures and compare fractures with >15° of impaction (31-B1.1) against fractures with <15° of impaction (31-B1.2).

Methods: Between February 2005 and November 2010, 89 femoral neck fractures with valgus deformity (31-B1.1 and 31-B1.2) were treated by screw osteosynthesis. The valgus impaction was not disimpacted; however, posterior tilt of the capital fragment (apex anterior angulation) was reduced by internally rotating the leg and applying pressure from the front. A total of 78 patients were followed for >12 months. We evaluated the clinical and radiographic outcomes.

Results: 36 patients sustained 31-B1.1 fractures, and 42 patients sustained 31-B1.2 fractures. The average follow-up period was 15 months, and bony union occurred in all cases. The mean femur neck shortening was 8.88 mm for B1.1 and 3.70 mm for B1.2 fractures (P <0.001). The mean sliding distance of the screw (SS) was 3.36 mm for B1.1 fractures and 1.38 mm for B1.2 fractures (P <0.001). The mean Harris Hip Score was 82.0 for B1.1 and 88.8 for B1.2 fractures (P = 0.029). Osteonecrosis (ON) of the femoral head occurred in 4 patients with B1.1 fractures and none with B1.2 fractures (P = 0.041). 18 of the 78 patients required a second operation and 15 of them were included in 31-B1.1 fracture (P = 0.003). Three patients underwent arthroplasty due to ON, and 15 patients required hardware removal due to pain after bony union.

Conclusion: More femoral neck shortening and less functional recovery should be expected in the valgus impacted femoral neck fracture patient based on the severity of initial deformity. Even though we could obtain bony union in all of the cases, the risk of ON and second operation after bony union was higher with greater initial deformity.

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•Fixation of Displaced Femoral Neck Fractures in Young Adults: Fixed-Angle Devices or Pauwel Screws?

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Purpose: Traditional parallel screws have been shown to perform poorly compared to fixed-angle devices for displaced femoral neck fractures. However, many North American trauma surgeons use Pauwel screws that feature a lag screw directed from the greater trochanter inferiorly towards the calcar instead of parallel screws. Our hypothesis was that Pauwel screws would perform as well as fixed-angle devices for these fractures.

Methods: A retrospective analysis of consecutive femoral neck fractures was performed using our prospectively maintained database. From January 2001 to June 2012, 205 femoral neck fractures in young adults (16-60 years old) were treated with internal fixation at our Level I trauma center. After excluding patients with nondisplaced fractures (72), parallel screw configurations (20), locking plates (8), cephalomedullary nails (2), and <6 month follow-up (41), 2 cohorts were formed. The fixed-angle group consisted of 47 patients (48 hips) that were treated with a side plate and screw/blade device (DHS/DHHS, Synthes), while in the screw group 15 patients (15 hips) were treated with a lag screw placed from the greater trochanter into the inferior neck followed by multiple cancellous screws parallel to the femoral neck. The quality of reduction was judged using the Haidukewych criteria. There were no significant differences between the treatment groups with regard to age, sex, initial displacement, time to surgery, or reduction quality (all $P > 0.05$). An open reduction was performed in 95% of cases resulting in a good-excellent reduction in 83% of cases (Table 1). The average follow-up was 17.2 months.

Table 1: Reduction Quality

	Excellent	Good	Fair	Poor	Total
Fixed-angle group	27 (56%)	13 (27%)	5 (10%)	3 (6%)	48
Screw group	8 (53%)	4 (27%)	3 (20%)	0 (0%)	15

The primary outcome measure was a composite failure metric of a completed or scheduled operation to treat ON (osteonecrosis) or nonunion.

Results: There were significantly more failures in the screw group (60%) compared to the fixed-angle group (21%) ($P = 0.008$) (Table 2). ON was rare in the fixed-angle group, occurring in 2% of cases versus 33% in the screw group ($P = 0.002$). Consistent with prior work, good-excellent reductions had a failure rate of 31% compared to 64% with a fair-poor reduction ($P = 0.08$). The best-case scenario of a good-excellent reduction with a fixed-angle device yielded a success rate of 85%.

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Table 2: Results

	Fixed-Angle Group	Screw Group	*P* Value
Composite failure	10 (20.8%)	9 (60.0%)	0.008
ON	1 (2.1%)	5 (33.3%)	0.002

Conclusion: Despite the theoretical mechanical advantage of Pauwel screws over parallel screws, this screw configuration still performed poorly compared to fixed-angle devices. In young patients with high-energy femoral neck fractures, lower complication rates are observed with anatomic reduction and fixed-angle devices.

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SKILLS LABS

Surgical Implant Generation Network (SIGN) *(#SL3)*
Lab Leader: L*ewis G. Zirkle, Jr., MD*
Faculty: *Prof. Shabab-Uddin, MD; John W. Staeheli, MD; Kyle R. Stephens, DO; Paul S. Whiting, MD* and *Frederic B. Wilson, Jr., MD*

IM Fixation of Proximal Tibial Fractures *(#SL4)*
Lab Leader: *Roy Sanders, MD*
Faculty: *Daniel R. Dziadosz, MD; Joshua Langford, MD; Frank Liporace, MD; Anthony S. Rhorer, MD* and *William M. Ricci, MD*

Knee or Ankle Spanning Ex-Fix *(#SL5)*
Lab Leader: *Edward A. Perez, MD*
Faculty: *Hassan R. Mir, MD; Amer J. Mirza, MD; Matthew I. Rudloff, MD; John C. Weinlein, MD* and *Robert D. Zura, MD*

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MINI SYMPOSIA

Contemporary Debates in Orthopaedic Trauma
Moderator: *Michael Suk, MD, JD*
Faculty: *Samuel G. Agnew, MD; Bruce D. Browner, MD; Lisa K. Cannada, MD; Clifford B. Jones, MD; A. Alex Jahangir, MD; Douglas W. Lundy, MD; Theodore Toan Le, MD; Samir Mehta, MD; Manish K. Sethi, MD; Philip R. Wolinsky, MD* and *Bruce H. Ziran, MD*

Financial Implications of Increasing ACS Trauma Level: Where Does the Orthopaedic Trauma Surgeon Fit into the Equation?
Moderator: *Timothy J. Bray, MD*
Faculty: *Peter Althausen, MD; Austin Hill, MD, MPH* and *Mike Williams, MPA, HSA*

Introduction to ICD-10 for Orthopaedic Traumatologists
Moderator: *M. Bradford Henley, MD*
Faculty: *J. Scott Broderick, MD* and *William R. Creevy, MD*

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SYMPOSIUM II: ASSESSMENT OF FRACTURE REPAIR

Moderators: *Emil H. Schemitsch, MD*
Theodore Miclau, III, MD

12:30 pm **What is the Problem and is there a Consensus?**
Michael D. McKee, MD

12:40 pm **Current Options for Determining Union**
Saam Morshed, MD, PhD

12:50 pm **What is the Role for Functional Outcomes?**
Gerard P. Slobogean, MD, MPH

1:00 pm **Are Fracture Healing Trials a Thing of Past: The Challenge of FDA**
Paul Tornetta, III, MD

1:10 pm **Focusing Our Efforts: Challenging Healing Problems, but What Will the Answers Be?**
Michael J. Bosse, MD

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Is There an International Consensus as to How to Assess Fracture Healing Based on Clinical and Radiological Findings?

Wojciech Glinkowski, MD, PhD[1]*; Jakub Janowicz, MD*[1]*; Alexander N. Chelnokov, MD*[2]*;*
[1]*Department of Orthopaedics and Traumatology of Locomotor System, Center of Excellence "TeleOrto" (Telediagnostics and Treatment of Disorders and Injuries of Locomotor System), Medical University of Warsaw, Warsaw, Poland;*
[2]*Ural Scientific Research Institute of Traumatology and Orthopaedics, Ekaterinburg, Russia*

Purpose: The lack of consensus and variability among orthopaedic surgeons in the assessment of fracture healing was reported in the literature. The aim of the study was to survey orthopaedic surgeons as to how they do this in clinical practice.

Methods: Orthopaedic surgeons/fracture researchers personally involved in fracture treatment were surveyed over the Internet. Personal e-mails containing an individual invitation to respond on the Internet-based survey were sent to 350 corresponding authors of articles published on fracture treatment. Additionally, an invitation was shared over orthopaedic trauma groups on social network portals. Eighty orthopaedic surgeons/researchers responded to the survey. We created an International Survey on Fracture Healing Assessment Methods through the survey portal (mini-ankiety.pl). The link to the survey was sent in every e-mail (http://www.mini-ankiety.pl/Survey/Take/30).

Results: The survey respondents came from 23 countries (Australia, Austria, Belarus, Canada, China, Colombia, France, Germany, Greece, India, Italy, Japan, Kazakhstan, Malaysia, Nigeria, Poland, Russia, Serbia, Sweden, Switzerland, Ukraine, USA, and Uzbekistan). Forty of them were Board-certified and forty during their residencies. The average age of respondents was 42.09 years (standard deviation 12.21). 83.75% consistently or ordinarily use specific clinical criteria to define a fracture union. Physical examination criteria are regularly or usually observed as follows: the absence of pain or tenderness on palpation, 87.50%; the absence of pain/tenderness when bearing weight, 95%; no pain/tenderness on examination, the ability to bear weight, 90%; and the ability to walk/perform activities of daily living with no pain, 82.50%. Any kind of fracture stiffness mechanical measurement is performed regularly or usually in 27%. Ultrasound propagation measurement, vibration analysis, impulse response analysis, or resonant frequency analysis are not performed in 67.5% to 85%. Radiographic modalities are constantly used by 92.5% of surveyed professionals. Surgeons rarely declared the regular use of advanced imaging technologies (CT - 7.5%, ultrasound - 6.25%, MRI - 5%, and scintigraphy - 3.75%). Interestingly, only 31.25% of international respondents always use AO/OTA fracture classification, 17.5% usually, 20% often, 18.75% sometimes, and hardly ever 12.5%. Semiquantitative scoring is seldom performed (7.5% - 8.75%). Bone densitometry (DEXA or QCT) is rarely used (11.25% and 16.25%, respectively).

Conclusion: Except for some recent approaches, fracture healing assessment studies remain semiquantitative and subjective due to the lack of consensus described in the orthopaedic literature and absent internationally proven quantitative methods. It is still not standardized in clinical practice as seen in this study. Further international incentives are mandatory to

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achieve a more standardized approach for valid and reliable clinical or radiological measures of the union, at least for the interpretation of fracture care trials. We have launched Spanish, Chinese, and Japanese versions of the survey already.

Funding: This study was supported by research grant N403 171340 from the National Science Centre.

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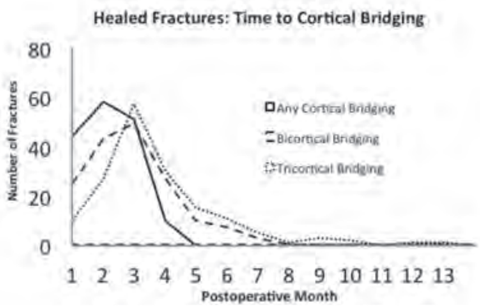
Any Cortical Bridging Predicts Healing of Tibial Shaft Fractures

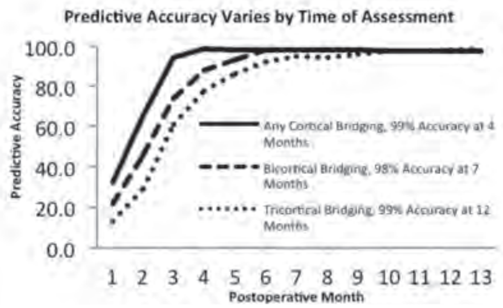
William Lack, MD*; James Starman, MD; Rachel Seymour, PhD; Michael J. Bosse, MD; Madhav Karunakar, MD; Stephen Sims, MD; James Kellam, MD*
Carolinas Medical Center, Charlotte, North Carolina, USA

Background/Purpose: There is no consensus regarding the optimal radiographic criteria for predicting the final healing of fractures or when these criteria should be employed. Given that healing occurs over time, the accuracy of radiographic criteria for predicting union is time-dependent. The purpose of this study was to determine the accuracy of unicortical, bicortical, and tricortical bridging in predicting the final healing of tibial shaft fractures treated with intramedullary nailing and to determine when these assessments are most accurate during the postoperative period.

Methods: A retrospective review at a Level I trauma center identified 176 tibia fractures (OTA 42-A,B,C) treated with intramedullary nailing over a 3-year period. All postoperative digital radiographs were assessed for the presence of varying degrees of cortical bridging. Receiver operating curve (ROC) and χ^2 analyses determined the accuracy of predicting union by assessing for the degree of radiographic cortical bridging at various postoperative time points.

Results: The nonunion rate was 7.4% (13 of 176 fractures). Any cortical bridging by 4 months postoperatively was an excellent predictor of final healing (accurate in 174 of 176 fractures, ROC curve area 0.995, *P* <0.0001) and was the most reliable criterion (kappa 0.90). All fractures bridging a single cortex within the first 4 months eventually bridge three cortices with observation alone. Bridging of additional cortices did not improve the predictive accuracy (ROC curve area 0.975 and 0.990 for bridging of two and three cortices, respectively, *P* <0.0001 for both). Additionally, these more stringent criteria were not accurate until 7 months for two cortices and 12 months for three cortices and were less reliable (kappa 0.74 for two cortices and 0.78 for three cortices).





Conclusion: Assessment for any cortical bridging by 4 months postoperatively accurately predicts final healing of tibial shaft fractures and has a high reliability. This relatively early radiographic finding discriminates between fractures achieving late union with observation alone and those destined to nonunion. Requiring additional cortices to be bridged does not

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add predictive value and risks overestimation of the nonunion rate. Assessment for any cortical bridging at 4months may guide early intervention in appropriate patients while avoiding unnecessary surgery in others.

Ultrasonographic Monitoring of Fracture Healing: Is This the End of Radiography in Fracture Follow-ups?

Sourabh Chachan, MBBS; *Barsha Tudu, MBBS, MS (orth); Biswajit Sahu, MBBS, MS (orth);*
VSS Medical College, Burla, Sambalpur, Orissa, India

Purpose: This study was conducted with the aim to compare the efficiency of ultrasonography and radiography in monitoring fracture healing process and to further define the role of ultrasonography in following-up fracture cases. The hypothesis was that fracture healing, being a soft-tissue process in the earlier stages with bone formation occurring only in the later stages, should be better monitored by a modality evaluating soft tissues like ultrasonography, unlike radiography, which basically evaluates hard structures like bones.

Methods: A prospective follow-up study was conducted at the department of orthopaedics of a tertiary care center from October 2011 to October 2012. The study included 48 (male = 32, female = 16) cases of acute closed fracture of tibial diaphysis located in the mid-third. All the cases were treated by closed reduction and internal fixation with reamed static locked tibial interlocking nail, as soon as possible. All the patients were followed up for an average period of 24 weeks (range, 14-52 weeks). For every case, fortnightly evaluation was done using both ultrasonography and radiography. Ultrasonographic criterion for fracture healing was set as progressive appearance of periosteal callus with complete disappearance of nail at union. Radiographic criterion for fracture union was set as appearance of bridging callus at all the four cortices.

Results: Most of the cases were in the age group of 22 to 33 years and 80% of the total cases were result of road traffic accidents. 40% of the cases were classified as OTA 42-A2 fractures. Categories OTA 42-A1, A3, B1, and B2 constituted 17%, 23%, 10.5%, and 10.5% of the cases, respectively. Out of 48 cases, 38 achieved union, 4 went into non-union, and 6 developed delayed union. It was observed that using the above criteria, fracture union can be diagnosed at an average of 2 weeks earlier on ultrasonography as compared to radiography. Four out of six cases of delayed union and all nonunion cases also declared themselves much earlier on ultrasonography than radiography.

Conclusion: Use of ultrasonography for monitoring of fracture healing process has a clear advantage over radiography. It provides valuable early information about union and also accurately predicted delayed unions and nonunions at a very early time. Thus it can be presumed that using ultrasonography instead of radiography in follow-up of fracture cases can help in early diagnosis and intervention for unfavorable fracture healing outcomes.

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MINI SYMPOSIA

Technical Tips in 3 and 4-Part Proximal Humerus ORIF
Moderator: *Utku Kandemir, MD*
Faculty: *Michael J. Gardner, MD; John T. Gorczyca, MD; Michael D. McKee, MD* and *Milan K. Sen, MD*

How to Establish and Run a Fragility Fracture Program
Moderator: *James A. Goulet, MD*
Faculty: *Kyle J. Jeray, MD; Clifford B. Jones, MD; Joseph M. Lane, MD* and *Marc F. Swiontkowski, MD*

Healthcare Systems and Trauma:
A 360 Degree World View for the Orthopaedic Trauma Surgeon
Moderator: *Manish K. Sethi, MD*
Faculty: *James R. Ficke, MD; Samir Mehta, MD* and *Hassan R. Mir, MD*

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Are Locked Plates Needed for Fixation of Split Depression Tibial Plateau Fractures (Schatzker Type II)?

Michelle Abghari, BS*; Alejandro I. Marcano, MD; Roy Davidovitch, MD; Sanjit Konda, MD; Kenneth A. Egol, MD;*
NYU Hospital for Joint Diseases, New York, New York, USA

Background/Purpose: Displaced tibial plateau fractures most often need surgical treatment. Usually a plate and screw construct is used in treatment of these fractures. Locking plate technology has seen an increase in usage for both complex and simple fracture patterns without evidence demonstrating their efficacy. The purpose of this study is to compare the clinical use of locked versus unlocked plating for repair of displaced Schatzker type II tibial plateau fractures.

Methods: 91 consecutive patients treated surgically for Schatzker type II tibial plateau fractures were prospectively seen over a 5-year period. 42 patients (46.2%) were treated using a locked plate and screw construct and 49 (53.8%) were treated with an unlocked plate and screw construct. Pre- and postoperative care, plate morphology and length, and patient demographic factors were similar in both groups. Clinical outcomes of the two groups were assessed using Short Musculoskeletal Function Assessment (SMFA) scores, pain levels, and range of knee motion. Radiographic outcome was assessed with plain films at all follow-up points. Implant costs for the 2 types of constructs were calculated from hospital purchasing records.

Results: Patients were assessed at a mean 13.9 months (range, 6-72) of follow-up. Comparing patients treated with locked versus unlocked constructs, no significant differences were seen in physical exam parameters or radiographic outcomes. Total SMFA scores did not differ; however, the SMFA Functional Domain was significantly better in the unlocked group (Table 1). The locked construct cost an average $400 more than the unlocked construct.

Patients Treated With Locked and Nonlocked Plating

	Length of Stay (days)	Time to Fracture Union	Residual Depression	Degree of Mechanical Alignment	ROM Extension	ROM Flexion	Pain
Locked	4.4	3.8	1.2	87.0	1.0	121.6	3.7
Nonlocked	3.3	3.6	0.8	87.4	1.0	125.1	2.9
P value	0.50	0.66	0.22	0.34	0.98	0.39	0.20

ROM = range of motion.

Conclusion: Based on the clinical outcomes and cost per implant, we can find no evidence to support the routine use of locked plating for simple split depression fractures of the lateral tibial plateau. The use of standard nonlocked, precontoured implants provide adequate fixation for these fracture patterns.

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Δ Inflammatory Cytokine Response Following Tibial Plateau Fracture Does Not Correlate with Fracture Grading of "Low Versus High Energy"

Justin Haller, MD; *Erik Kubiak, MD; Thomas F. Higgins, MD;*
University of Utah, Salt Lake City, Utah, USA

Purpose: This study is designed to evaluate the inflammatory cytokine response following intra-articular tibial plateau fracture. Prior studies have linked both inflammatory response and grade of injury to the development of arthritis, and we hypothesized that higher grade fractures would have a more robust inflammatory response.

Methods: After IRB approval, investigators prospectively aspirated synovial fluid from the injured and uninjured knees of 23 patients with tibial plateau fractures who were between the ages of 18 and 60 years. Patients with open fracture, history of autoimmune disease, preexisting arthritis, or presentation greater than 24 hours from injury were excluded. The 10 patients requiring spanning external fixator followed by definitive fixation were aspirated at both surgeries. The concentrations of 15 inflammatory cytokines (interferon [IFN]-γ, interleukin [IL]-2, -4, -6, -7, -8, -10, -12 (p70), -13, -17, -1β, -1Ra, tumor necrosis factor [TNF]-α, monocyte chemotactic protein [MCP]-1, and macrophage inflammatory protein [MIP]) were quantified using a human inflammatory cytokine multiplex panel.

Results: We enrolled 23 patients (9 females, 14 males), with an average age of 44.3 years (range, 20-60). There were 9 low-energy (OTA 41B or Schatzker 1-3, all OTA 41B) tibial plateau injuries and 14 high-energy (Schatzker 4-6) tibial plateau injuries. Of the high-energy fractures, 5 were OTA 41B3 and 9 were OTA 41C. There was a significant difference between injured and uninjured knees in all cytokines except IL-1β, IL-1Ra, IL-2, IL-7, and IL-12p70 (P = 0.15, 0.20, 0.08, 0.10, 0.11, respectively). There was no difference in inflammatory response between high- and low-energy injuries for any of the cytokines (see table below). IL-7, MCP-1, and TNF-α all remained elevated at an average of 8.5 days from initial surgery. While not significant, IL-1Ra experienced an increase in concentration between the two time points ($P = 0.24$). All other cytokine concentrations decreased between index and secondary surgery.

Conclusion: There is a significant inflammatory response in most of the cytokines tested in the injured knee compared to the control knee, demonstrating the effect to be local, not systemic. Most surprisingly, there was no difference in inflammatory response between high- and low-energy injuries. While there is an established link between inflammatory cytokines and the development of arthritis, in these patients with articular injury, the inflammatory response is not correlated to the grading systems commonly used to distinguish high energy versus low energy.

Δ OTA Grant
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Time 0 Cytokine Comparison of High-Energy to Low Energy Injuries (Not All Cytokines Listed Here)

	High Energy (n = 14)	Low Energy (n = 9)	Mean Diff (95% Confidence Interval)	*P* Value
IFN-γ	15.19 (14.69)	58.67 (18.32)	–43.48 (–92.31, 5.35)	0.08
IL-1Ra	270.11 (93.00)	113.20 (116.04)	156.91 (–153.62, 467.45)	0.30
IL-1β	6.47 (3.13)	2.57 (3.92)	3.90 (–6.6, 14.41)	0.45
IL-2	8.29 (5.93)	15.38 (7.41)	–7.09 (–27.04,12.86)	0.47
IL-6	41,539 (6381)	33,658 (8003)	7881 (–13,730, 29,493)	0.27
IL-7	42.4 (3.13)	33.94 (3.91)	8.46 (–2.03, 18.94)	0.31
IL-8	846.81 (176.03)	635.53 (220.87)	211.27 (–385.53, 808.08)	0.47
MCP-1	14,610 (4864)	5260 (6261)	9350 (–8285, 26,986)	0.28
MIP-1β	375.43 (98.9)	442.72 (123.9)	–67.29 (–401.17, 266.59)	0.68
TNF-α	41.68 (4.82)	44.56 (6.02)	–2.87 (–18.98, 13.25)	0.71

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•Fix It or Discard It? A Retrospective Review of Functional Outcomes After Surgically Treated Patellar Fractures Comparing Open Reduction and Internal Fixation With Partial Patellectomy

Nicholas Bonnaig, MD; Chris Casstevens, MD; ***Michael T. Archdeacon, MD, MSE****;*
University of Cincinnati Department of Orthopaedic Surgery, Cincinnati, Ohio, USA

Background/Purpose: The goals of surgical treatment of patellar fractures are to provide a congruous articular surface and restore the quadriceps extensor mechanism. To achieve these goals open reduction and internal fixation (ORIF) is the operative technique of choice when anatomic reduction is possible. In comminuted fractures where some fragments are unreconstructable, partial patellectomy (PP) offers an alternative means of restoring the extensor mechanism. The prognosis for these procedures is not clear; thus, the goal of this study was to compare functional outcomes of patients treated with ORIF to those treated with PP.

Methods: We identified 73 patients with isolated displaced patella fractures who underwent surgical treatment between 2002 and 2009 at our institution. Of the 73 qualifying patients, 52 patients (71%) with isolated unilateral patellar fractures with a minimum of 1-year follow-up agreed to participate and were enrolled in the study. Patients completed outcome questionnaires, visual analog pain scale (VAS), and participated in a physical exam including evaluation of gait, passive range of motion and the presence or absence of an extensor lag. Standard AP and lateral radiographs were also collected to assess fracture healing. Outcome instruments included the Knee Outcome Survey – Activities of Daily Living scale (KOS-ADLS), Short Form-36 (SF-36) Health Survey, and Short Musculoskeletal Function Assessment survey (SMFA).

Results: Of the 52 patients who agreed to participate, 26 underwent partial patellectomy and 26 underwent ORIF. There were no significant differences in age, sex, or preinjury functional status between the two groups. The mean follow-up time was 35 months in the PP group and 33 months in the ORIF group. There were no significant differences in any of the functional outcome instruments including KOS-ADSS (ORIF: 64.1 ± 11 vs PP: 62.1 ± 7.9; $P = 0.76$), SF-36 Physical Component score (ORIF: 40.8 ± 5.4, vs PP: 41.1 ± 5.2; $P = 0.94$), SF-36 Mental Component (ORIF: 47.7 ± 5.1 vs PP: 51.8 ± 4.9; $P = 0.19$), SMFA Function Index (ORIF: 28.6 ± 9.1 vs PP: 27.7 ± 6.7; $P = 0.78$) or SMFA Bother Index (ORIF: 26.0 ± 9.7 vs PP: 23.6 ± 8.8; $P = 0.72$). There was also no significant difference in pain as assessed by VAS (ORIF: 2.8 ± 1.35 vs PP: 2.9 ± 1.0; $P = 0.27$). There were more patients in the ORIF group who had an extensor lag greater than 5° at follow-up; however, this did not achieve statistical significance (ORIF: 2/26 [7%] vs PP: 5/26 [19%]; $P = 0.42$). There was no significant difference in total range of motion between the two groups (ORIF: 114 ± 27° vs PP: 119 ± 17°; $P = 0.42$). Complications included 14 secondary procedures for removal of hardware (ORIF: 8/26 [31%] vs 6/26 [23%]; $P = 0.76$), 4 nonunions (ORIF: 3/26 [12%] vs PP: 1/26 [3.8%]; $P = 0.6$), and 2 incidences of knee arthrofibrosis (ORIF: 1/26 [4%] vs PP: 1/26 [4%]; $P = 1.0$).

Conclusion: This study demonstrates that functional impairment persists after surgical treatment of patellar fractures. Both ORIF and PP demonstrated similar final range of mo-

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tion, functional scores, and complication rates. Despite its purported benefits, in this study ORIF did not result in superior outcomes compared to PP.

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•Time to Spanning External Fixation for High-Energy Tibial Plateau and Plafond Fractures has No Impact on Rates of Infection, Compartment Syndrome, or Secondary Procedures

Justin Haller, MD; *David Holt, MD; Erik Kubiak, MD; Thomas F. Higgins, MD;*
University of Utah, Salt Lake City, Utah, USA

Purpose: The purpose of the study is to retrospectively investigate if the time delay to spanning external fixation of high-energy tibial plateau and plafond fractures had any impact on rate of complications, time to definitive fixation, secondary procedures, and length of stay (LOS). Our hypothesis is that these outcomes will be no different in patients who underwent early versus late fixation.

Methods: We retrospectively reviewed patients greater than 18 years of age who presented to our Level I trauma center with a high-energy tibial plateau (Schatzker IV-VI) or tibial plafond fracture requiring provisional external fixation followed by definitive repair from 2006-2012. Patients were excluded if they had less than 6 months of follow-up or did not receive both the temporizing and definitive surgeries at our institution. Patients who received surgery <12 hours after injury were classified as early external fixation (EEF) and those who underwent surgery >12 hrs after injury constituted the delayed external fixation group (DEF). Demographic data including age, sex, tobacco use, mechanism, and comorbidities were recorded. Infection, LOS, time to definitive fixation, and secondary surgeries (after definitive fixation) were recorded.

Results: Between 2006 and 2012, 215 (109 tibial plateaus and 96 tibial plafonds) fractures met inclusion criteria. 63 (39 plateaus and 24 plafonds) patients were excluded for <6 months follow-up. There were 76 patients (37 plateaus and 38 plafonds) in the EEF cohort with a mean age of 41.8 (range, 20-77) and 72% were male. There were 66 patients (33 plateaus and 34 plafonds) in the DEF cohort with a mean age of 43.2 (range, 19-66) and 70% were male. Average follow-up was similar between early (13.4 months; range, 6-68) and delayed (16.47 months; range, 6-70) groups ($P = 0.17$). Subgroup analysis of plafond fractures demonstrated there were 24 open injuries (33.3%) and an overall infection rate of 22.2%. Similarly, there were 7 open plateau fractures (10%) and an overall infection rate of 20%. There were significantly more open plafonds in the early group ($P = 0.045$), but there was no significant difference in the number of open plateau fractures in the early group ($P = 0.11$). Using linear regression controlling for open fracture, there was no significant difference in infection between early versus late fixation for plafond fractures ($P = 0.42$) or plateau fractures ($P = 0.32$). Overall rate of compartment syndrome was 8.6% in plateau fractures and 7.9% in plafond fractures; these rates were no different between EEF and DEF for plateaus ($P = 0.29$) or plafonds ($P = 1.0$). There was no difference between EER and DEF for LOS for plafond fractures ($P = 0.88$) or plateau fractures ($P = 0.12$). Plateau fractures in the EEF group underwent definitive fixation a mean of 8.46 days after initial fixation compared to 11.5 days for those in the DEF group ($P = 0.058$). There was no difference in time to definitive fixation for plafond fractures ($P = 0.80$). Overall, 61% of plateau and 46% of plafond patients required secondary surgery. There was no difference in number of patients requiring secondary surgeries or overall number of secondary surgeries between early and delayed fixation for either plateau ($P = 0.46$, $P = 0.19$) or plafond fractures ($P = 0.10$, $P = 0.11$).

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Conclusion: There is no detectable difference in rates of infection, secondary surgeries, or hospital stay between patients with high-energy tibial plateau or plafond fractures receiving provisional external fixation <12 hours versus >12 hours. There was a trend toward fewer days to definitive fixation in patients with a plateau fracture who were spanned early; this difference was not present for plafond fractures.

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Intramedullary Nailing With an Internal Compression Device for Transverse Tibial Shaft Fractures Decreases Time to Union When Compared to Traditional "Backslapping" and Dynamic Locking

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Purpose: This study was conducted to compare the time to union and union rate for transverse tibial fractures treated with compression applied through the intramedullary rod or traditional technique of compression by "backslapping" and dynamic locking.

Methods: This was a retrospective analysis of skeletally mature patients with a transverse diaphyseal tibial fracture (OTA 42-A3) managed at a single institution between 2005 and 2012. Group 1 consisted of 22 patients managed with an intramedullary nail having the ability to apply controlled fracture compression using an internal compression device. Group 2 consisted of 32 patients managed with traditional "backslapping" and use of a single interlocking screw placed in the dynamic mode. All patients were permitted immediate weight bearing as tolerated. Inpatient and outpatient charts as well as complete radiographs were reviewed to determine patient demographics, injury characteristics, and time to radiographic and clinical union. Union was defined as the presence of bridging bony callus on at least three cortices and pain-free full weight bearing. Patients were excluded from analysis if they had inadequate follow-up, incomplete radiographs, or the mode of compression could not be ascertained from operative reports.

Results: Both groups were similar with respect to age, gender, fracture location and soft-tissue injury, use of bone stimulators, patient comorbidities, and weight-bearing allowance. The time to radiographic and clinical union was 103 days for group 1 versus 148 days for group 2 ($P = 0.018$). When patients treated with bone stimulators and/or bone morphogenetic proteins were excluded, the time to union was 88 days for group 1 versus 143 days for group 2 ($P = 0.002$). The incidence of nonunion was 0% in group 1 versus 9% (3 patients) in group 2; this difference was not statistically significant due to insufficient power.

Conclusion: Transverse tibial shaft fractures treated with an intramedullary rod with an internal compression device have a significantly shorter time to union and may have an overall lower nonunion rate compared to traditional intraoperative "backslapping" and dynamic locking.

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Can All Tibial Shaft Fractures Bear Weight Following Intramedullary Nailing? A Randomized Clinical Trial

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Background/Purpose: There currently exists no consensus regarding the appropriate postoperative weight-bearing status following intramedullary (IM) nailing of tibial shaft fractures. This prospective randomized study was designed to examine the potential benefits or risks associated with immediate postoperative weight bearing versus non–weight bearing. The null hypothesis was that early weight-bearing status had no effect on outcome following tibial nailing.

Methods: Over a 2.5-year period 60 tibial shaft fractures (OTA Type 42) indicated for surgical treatment with an IM nail that met inclusion criteria were identified. Patients were asked to consent to randomization of their postoperative protocol. Patients were randomized to one of two groups: immediate weight bearing as tolerated (WBAT), or non–weight bearing for the first 6 postoperative weeks (NWB). Regular follow-up was obtained, including radiographs. The Short Musculoskeletal Function Assessment (SMFA) questionnaire was used to record functional outcomes at regular intervals. Patients were followed until union or until treatment failure/revision surgery. All complications were recorded.

Results: A total of 46 patients with 48 tibia fractures had complete follow-up. The WBAT and NWB groups did not differ with regard to demographics, ISS, open/closed fracture status, or fracture pattern. There was no difference in the observed time to union between groups. Rates of complications, including hardware failure and delayed/nonunion, did not differ between groups. No incidents of significant loss of reduction leading to malunion were recorded. SMFA scores for all domains were similar between groups, both at 6 weeks postoperatively and at union.

Conclusion: Immediate weight bearing following IM nailing of tibial shaft fractures is safe and is not associated with an increase in adverse events or complications. Patients should be allowed to bear weight as tolerated following IM nailing. This has potential implications in improving patient satisfaction, earlier return to work, and faster rehabilitation.

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Does a 6-Month Wait Before Reoperation Improve Tibial Nonunion Rates? A Comparative Examination of Patients Not Enrolled in SPRINT

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Purpose: The SPRINT trial had lower than expected reoperation rates for nonunion based on previous literature (5% vs 11%), and it was hypothesized that the 6-month prohibition against reoperation was a major contributing factor. We compared rates and timing of reoperation in a subset of patients enrolled in SPRINT to those who were eligible but not enrolled to evaluate the effect of the 6-month waiting period and assessed the influence of a large randomized controlled trial on a parallel observational cohort.

Methods: The billing records of 6 of the SPRINT centers were searched for current procedural terminology (CPT) codes indicating intramedullary nailing of a closed tibia fracture and reoperation for fracture healing. Patients were grouped into SPRINT and unenrolled patients, and the rate and timing of reoperation were compared. A Fisher exact test was used to compare categorical variables and a Student *t* test was used to compare continuous variables. $P < 0.05$ was considered significant.

Results: 114 unenrolled patients were compared to 328 patients enrolled in SPRINT from the 6 sites. 105 (92%) underwent reamed nailing versus 167 (51%) of the SPRINT patients ($P < 0.001$). There were 7 reoperations (6.1%) in unenrolled patients versus 18 (5.5%) in SPRINT patients (odds ratio [OR] 1.13, 95% confidence interval [CI] 0.39 to 2.92; $P = 0.815$). There was no difference in the time to reoperation for nonunion (6.3 vs 6.8 months, 95% CI of the difference –3.75 to 2.65; $P = 0.701$). The proportion of patients who underwent reoperation before 6 months was substantially but not statistically significantly higher in the unenrolled patients (28% vs 43%, OR 1.9, 95% CI 0.20 to 16.53; $P = 0.640$).

Conclusion: Patients not enrolled in the SPRINT trial but who were treated at the same centers had similarly low rates of reoperation for nonunion following intramedullary nailing for closed tibial shaft fractures. A 6-month waiting period may explain the lower than expected rates. It is possible that clinical trials associated with improved outcomes may beneficially influence the care of nonenrolled patients; however, the extent of this influence requires further investigation. Parallel observational studies can be useful adjuncts to randomized controlled trials.

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What Is a "Critical Bone Defect" in Open Tibia Shaft Fractures Definitively Treated With an Intramedullary Nail?

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Background/Purpose: Tibia fractures are the most common long bone fractures representing 2% of all fractures with 12% to 23.5% open injuries, making them the most common open long bone injuries. When focusing on patients treated with intramedullary nailing (IMN), reported nonunion rates range from 3.4% to 18%. Currently, some treatments approaches include early, staged intervention for "critical bone defects". It is unclear when these staged treatments are indicated as the literature has yet to define the minimum threshold for bone loss requiring surgical intervention. This study aims to better define a "critical bone defect" based on clinical outcomes of union versus nonunion.

Methods: 180 patients age 18 to 65 years with open tibia diaphyseal fractures definitively treated with IMN from January 1, 2007to June 30, 2012 were retrospectively identified. 35 patients had 1 to 5 cm of bone loss on ≥50% of the cortices, at the time of definitive fixation, with a recorded outcome or at least 6 months of follow-up. Factors analyzed included: defect size, time to surgery, Gustilo-Anderson classification, number of procedures, use of additional fixation or biologic agents, deep infection requiring surgical intervention, presence of impaired vascular status, malignancy, diabetes, simultaneous injuries, autoimmune disease or immunosuppression, and total number of comorbidities. Average defect size measurements were calculated from cortical gap between bone fragments on standard AP and lateral radiographs. Analysis used a multivariate regression model to identify factors contributing to nonunion.

Results: Overall 50 of 180 patients with open tibial shaft fractures treated with IMN had defects of 1 to 5 cm on ≥50% of the cortices. 15 patients with qualifying defects were lost to follow-up. Patients achieving union averaged a defect size of 1.9 ± 0.5 cm/cortex, while those with nonunion averaged 3.0 ± 1.1 cm/cortex (P <0.01). No other covariates predicted healing outcomes. To further elucidate the definition of a critical bone defect, patients were group by bone defect size. Comparing patients with average cortical defects of 1 to 3 versus ≥3 cm revealed union rates of 61.5% and 0%, respectively (P = 0.018). Receiver operating characteristic curve analysis produced an area under the curve of 0.80, defining a 3-cm average defect as a good prognostic threshold for predicting union without intervention (P = 0.0001).

Conclusion: Determining initial injury factors that predict patient outcomes provide surgeons useful information for operative planning. Knowing the chances a patient will likely go on to nonunion at the time of initial fixation provides an opportunity to set both patient and surgeon treatment expectations. This study demonstrates that patients with a 1 to 3-cm average cortical defect have a high probability of achieving union. In patients with an average defect of ≥3 cm, nonunion was universal, thus increasing the value of early planned intervention. Diaphyseal bone grafting research addressing clinically significant differences should employ a conservative threshold for a "critical bone defect." An average

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cortical defect of ≥3 cm appears to be a reasonable threshold defect size. Limitations of this study include the retrospective nature and small cohort size. Further studies, including multicenter retrospective and prospective observational studies, are necessary to further characterize critical bone defects.

See pages 91 - 132 for financial disclosure information.

Alignment After Intramedullary Nailing of Distal Tibia Fractures Without Fibula Fixation

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Background/Purpose: Recent studies have shown lower rates of malalignment after intramedullary nailing of distal tibia shaft fractures with fixation of the fibula. However, fixation of the fibula brings with it risks of its own. The purpose of this study is to evaluate the efficacy of intramedullary nailing of distal tibia fractures using modern techniques without fibula fixation in obtaining and maintaining alignment and to evaluate the level of fibula fracture and the OTA tibial fracture type on alignment.

Methods: 137 consecutive patients with distal tibia fractures form the basis of this study. Demographic data, comorbidities (smoking, diabetes mellitus), mechanism of injury, fracture characteristics (open vs closed, OTA/AO classification, presence and location of fibula fracture), canal fill ratio, and the techniques used for reduction and nailing were documented. Malalignment (occurring in the operating room) and malunion (at union) were defined as greater than 5° of angulation on the initial postoperative AP or lateral radiographs and the final radiographs after union, respectively. Complications included unplanned secondary procedures (dynamization, exchange, removal locking screws), infection, wound dehiscence and delayed/nonunion. The effect of the OTA fracture type and the presence of fibula fracture and its level on alignment were evaluated using analysis of variance.

Results: There were 137 consecutive patients (96 men and 41 women) aged 16-93 years (average 43) with 41 (30%) open and 96 (70%) closed fractures. Five patients with indirect ankle fractures were excluded. Ten were lost prior to complete union but are included in the analysis of postoperative alignment. Mechanism of injury did not predict presence or level of fibula fracture. Fibula fractures were proximal (39), at the level of (46), distal to (30), segmental (7), and absent (10) with respect to the tibia fracture. Varus/valgus and procurvatum/recurvatum angulation upon presentation was greatest when the fibula was fractured at the level of the tibia fracture ($P = 0.001$ and 0.028). Reaming was performed in 84% and distal locking was with two medial to lateral locking screws in 95% with 5% having an additional AP locking screw for coronal plane fracture or osteopenia. Three patients had blocking screws. 36 patients (26%) had intra-articular extension of which 20 were fixed with screws and or plate outside the nail. The ratio of the nail to narrowest canal diameter at the level of the tibia fracture averaged 1.93 (range, 0.5-3) and did not correlate with malalignment or malunion. The most common intraoperative reduction aids were nailing in relative extension, transfixion external fixation, and clamps at the fracture site. The most important factor was felt to be the ability to visualize the reduction in both planes through the point of distal locking. The overall malalignment rate was 2%. Two additional patients had hardware removal prior to union for wound complication or infection and united at 6° and 8° resulting in a final malunion rate of 3%. The OTA fracture type or level/presence of fibula fracture did not influence alignment ($P = 0.8$ and 0.9), malunion ($P = 0.9$ and 0.99), or the change in alignment during union, which averaged 0.9° and was within measurement error. There were 2 wound problems/infection, 5 delayed/nonunions, and 4 distal screw removals for irritation.

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Δ OTA Grant

Conclusion: We found an overall low rate of both malalignment (2%) and malunion (3%) after intramedullary nailing of distal tibial shaft fracture without fibula fixation. We conclude that when techniques that allow for visualization through distal locking are used, fibula fixation is not necessary to obtain or maintain alignment. Additionally, standard two medial to lateral screws distally affords adequate stability to hold the reduction during union with a 0.9° difference in the initial postoperative and final united films.

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Outcomes of the Patients With Cultured Pathogens at the Time of Nonunion Surgery

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Purpose: This study was conducted to evaluate the incidence and outcomes of patients who cultured positive (PCP) during the surgical treatment of long bone nonunion.

Methods: 288 consecutive patients referred to a tertiary care medical center with a long bone nonunion were consented and enrolled in a prospective database. 216 (75%) who had undergone previous surgery were cultured intraoperatively for aerobic, anaerobic, and fungal pathogens. Standard preoperative lab data were collected on all patients and infectious laboratory markers were ordered on patients suspected for infection. When applicable, patients were recultured at follow-up débridement or revision surgery. All patients with positive operating room cultures were treated in consultation with an infectious disease specialist who prescribed culture sensitivity directed intravenous antibiotics. Patients were followed for at least 1 year after our institution's first intervention. The primary outcomes assessed are wound complications, antibiotic use, healing, function, and readmission for further surgery.

Results: Initial operative cultures returned positive on 23.6% of patients with an additional 3.1% culturing positive during the course of secondary treatments. All long bones were represented in the sample, but the majority of positive cultures were from tibial nonunions (41.5%). Preoperative white blood cell counts, erythrocyte sedimentation rate, and C-reactive protein were significantly elevated among PCPs ($P < 0.02$). A significantly greater percentage of PCPs (46.7%) developed wound complications during follow-up visits ($P < 0.01$). Antibiotic use averaged 3.2 months, versus 3 days in all other patients ($P < 0.01$). Significantly more PCPs returned to the operating room for irrigation and débridement, averaging 1.3 visits per patient ($P < 0.01$). At 9.8 months, PCPs required an additional 3.5 months more than others to progress to union ($P < 0.02$). Poor outcomes appeared in the 3.1% of patients who initially cultured negative, but converted to positive during the course of treatment. Their mean healing time was 14.3 months. Overall, the PCP group was significantly more likely to undergo removal of hardware ($P < 0.01$) and revision surgery ($P < 0.05$). The poorest outcomes were seen in two of the PCPs (3.3%) who failed several revision surgeries and opted for amputation over further reconstruction attempts. At 1-year follow-up, PCPs reported significantly worse function on 5 of 6 Short Musculoskeletal Function Assessment indices ($P < 0.01$).

Conclusions: In a large sample of nonunion patients, the infected nonunion stood apart on essentially all measures of outcome. Positive operating room culture at any point during the management of long bone nonunion was a prognostic indicator of impaired healing and poorer long-term functional outcomes in this study.

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Acute Compartment Syndrome: Where Pressure Fails, pH Succeeds

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Background/Purpose: Failure to recognise and treat acute compartment syndrome (ACS) early leads to significant morbidity. Current practice is dependent on the use of clinical signs and intracompartmental pressure (ICP) monitoring to identify the syndrome but there is still debate regarding the accuracy and interpretation of these findings. A more direct and reliable system is required.

Methods: Patients admitted with limb injuries at risk of developing an ACS underwent intramuscular (IM) pH and ICP monitoring with regular clinical assessment for the presence of the syndrome during their hospital stay. Fasciotomies were performed on those with clinical and/or pressure-based evidence of an ACS as per the unit's protocol. All patients were subsequently assessed for evidence of a missed compartment syndrome during routine follow-up and at specific research clinics at 6 and 12 months.

Results: Of the 62 patients participating in the trial, 51 subjects completed the follow-up protocol and were therefore included in the final analysis. They were divided into 2 groups: those who had evidence of a compartment syndrome, either initially (fasciotomies [n = 13]), or at follow-up (no fasciotomies [n = 7]), and those who had no evidence of an ACS (n = 31). The sensitivity and specificity for the worst values for each variable were calculated allowing receiver operator characteristic (ROC) curves to be created. These identified an area under the curve of 0.921 for pH, 0.732 for absolute pressure, and 0.591 for delta pressure. To achieve a sensitivity of 95%, an absolute pressure of greater than 30 mm Hg was only 30% specific, and a delta pressure of less than 33 mm Hg was 27% specific, while IM pH was 80% specific at this level (pH <6.38).

Conclusion: This study highlights the issues concerning the current diagnostic methods for ACS and provides the breakthrough that has been long anticipated. Despite the dependence on clinical and pressure-based evidence for diagnosing ACS in this study, intramuscular pH radically outperformed both the highest ICP and the lowest delta pressure. Using IM pH to diagnose ACS, clinicians can confidently identify patients early and accurately, significantly reducing the morbidity associated with this syndrome.

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Interobserver Reliability in the Measurement of Lower Leg Compartment Pressures

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Purpose: Accurate measurement of compartment pressures may be crucial to the correct diagnosis of a compartment syndrome. Commercially available monitors have not been validated as reliable in clinical practice. We hypothesized that there would be significant interobserver variability in measuring compartment pressures in a simulated compartment syndrome cadaveric lower leg model.

Methods: Four above-knee cadaveric specimens were used to create a compartment syndrome model with consistent lower leg compartment pressures at a mean of 47 mm Hg. This pressure was monitored with indwelling slit catheters and the authors' serial measurements (standard deviation [SD], 2.8 mm Hg). 38 emergency department, general surgery, and orthopaedic surgery residents, fellows, and attending physicians examined the limb for firmness and a diagnostic impression assuming a diastolic blood pressure of 70 mm Hg. They assembled the compartment pressure monitor with a side-port needle and measured the pressure in the four compartments of the leg. They were observed for correct assembly of the monitor, reading the instructions, proper zeroing and flushing of the monitor for each measurement, and anatomically correct measurements. The measurements were recorded and compared to the standard pressure measurements.

Results: 47% of participants were clinically concerned for compartment syndrome based on the firmness of the leg. 61% of participants did not read the instructions. Of the 152 separate compartment measurements, 48 (31.6%) were made with proper technique, 45 (29.6%) were made with catastrophic errors in technique, and 59 (38.8%) with lesser variations in technique. Participants' level of training, experience using a compartment pressure monitor, and reading the monitor's instructions did not have a significant effect on the likelihood of making a catastrophic error nor did they have a significant effect on accuracy to within 5 mm Hg of the standard compartment pressure. Using proper technique significantly improved the accuracy of the measurements (P <0.005): 60% of proper technique measurements were within 5 mm Hg of the standard pressure while 42% of those with lesser variations in technique and 22% of those with a catastrophic error were within this range. Proper technique measurements were a mean of 5.9 mm Hg (SD 7.1) from the standard pressure while those with variant technique were a mean of 10.8 mm Hg (SD 12.8) and those with catastrophic errors in technique were a mean of 20.1 mm Hg (SD 14.0) from the standard pressures, respectively. This difference between the catastrophic error group and the other two groups was significant (P <0.001). 41% of measurements were below 40 mm Hg, which corresponded to a delta P of 30 mm Hg in this model. These would have resulted in the missed diagnosis of compartment syndrome.

Conclusion: There was significant variability in technique and results obtained with a compartment pressure monitor. Catastrophic errors and variations in technique were com-

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mon. Proper technique improved accuracy, but even with proper technique 40% of the measurements were at least 5 mm Hg from the correct pressure. We recommend review and education of proper technique for all clinicians measuring and diagnosing compartment syndrome. The numeric value obtained when measuring compartment pressure must be seen as an approximation.

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Displaced Medial Epicondyle Fractures in Children: Comparative Effectiveness of Surgical Treatment Versus Nonsurgical Treatment

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Purpose: The purpose of this study was to assess the comparative effectiveness of surgical versus nonsurgical treatment for pediatric patients with acute, displaced medial epicondyle fractures.

Methods: This retrospective, comparative study included 56 children (31 female, 25 male) under age 18 years with an acute, displaced medial epicondyle fracture treated between 2000 and 2011 and with at least 1 year clinical follow-up. Medical records were searched for demographic, surgical, and functional data (range of motion, pain, symptoms, and limitations). Displacement was measured on radiographic injury films. Patients were contacted by phone for completion of the validated QuickDASH (an abbreviated version of the Disabilities of the Arm, Shoulder and Hand [DASH] questionnaire. Outcomes of surgical and nonsurgical treatment were compared using Mann-Whitney and Fisher exact tests and linear regressions controlling for age and maximum displacement.

Results: Of the 56 patients (mean age, 11 years; range, 4-17) with displaced medial epicondyle fractures, 41 were treated surgically and 15 nonsurgically. The surgically treated patients were older (12.0 vs 9.6 years, $P = 0.036$), had greater maximum displacement (11.0 vs 7.9 mm, $P = 0.011$), and shorter immobilization (3 vs 4 weeks, $P = 0.014$) than the nonsurgically treated patients. The two groups did not differ in range of motion, pain, or patient-reported functional outcomes at most recent follow-up ($P > 0.05$). Fracture dislocations occurred in 41% (17 of 41) of surgically treated and 33% (5 of 15) nonsurgically treated patients. Patients with dislocated fractures were more likely to have long-term functional disability, regardless of age, maximum displacement, or treatment ($P = 0.040$). Complications occurred in 53% of patients (8 of 15) in the nonsurgical group and included arthofibrosis, two ulnar neuropathies, three refractures, and three nonunions. Seven nonsurgically treated patients advanced to surgical treatment within 3 years, and five had residual functional limitations.

Conclusion: Our findings demonstrate a high failure rate (47%) of nonsurgically treated medial epicondyle fractures. Nonsurgical treatment is only recommended for fractures without elbow dislocation that do not contain an intra-articular fragment.

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A Prospective Cohort Study of the Adoption of Titanium Elastic Intramedullary Nails for the Treatment of Femur Fractures in Kumasi, Ghana

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Background/Purpose: Elastic intramedullary nails (EIN) have been shown to be effective in the treatment of transverse and short oblique femur fractures in children. No studies have compared outcomes of EIN versus skin traction for pediatric femur fractures. At Komfo Anokye Teaching Hospital (KATH), prior to 2010, all pediatric femur fractures were treated with skin traction until union. This study was designed to compare the early results and cost of EIN versus skin traction and determine health-related quality of life (HRQOL) outcomes of children with femur fractures stabilized with EIN.

Methods: This was a prospective observational study of 83 pediatric patients age 3 to 14 years presenting with closed femur fractures at KATH from January to December 2010. Implant costs were borne by the patient's family. Those who did not purchase implants were treated with skin traction until union, and this comprised the control group. Patient and injury demographics, initial radiographs, postoperative radiographic outcomes, length of stay, and total costs were compared between groups. The child's HRQOL at 6 months was assessed using the pediatric quality of life inventory (PedsQL).

Results: There was significantly better radiographic alignment in the 45 children treated with elastic nails. Average posttreatment length of stay was 30.8 days in the traction group versus 15.6 days in the EIN group ($P = 0.001$). Cost of hospitalization was significantly lower in the EIN group($P = 0.039$). The mean HRQOL remained significantly lower in total score (63.4) and in all five subscales (physical health, 64.9; psychosocial health, 63.0; emotional functioning, 68.0; social functioning, 68.3; and school functioning, 51.33) than the general population mean at average 6-month follow-up.

Conclusions: In this prospective observational cohort study of pediatric femoral fractures in Kumasi, Ghana, treatment with EIN resulted in superior radiographic outcomes, shorter hospital stay, and decreased hospital cost in comparison to skin traction. At 6 months, HRQOL remained significantly impacted in children who sustained femur fractures stabilized by EIN.

See pages 91 - 132 for financial disclosure information.

Refracture Rates Following Clavicle Shaft Fractures in Children: Angulation-Only Fractures Versus Completely Displaced Fractures

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Purpose: A growing body of literature has focused on completely displaced clavicle fractures, but there has been remarkably little attention focused on angulated fractures. The purpose of this study was to assess refracture rates following angulation only and completely displaced clavicle shaft fractures in children.

Methods: We performed computerized medical records searches aimed at identifying children treated for clavicle shaft fractures at our institution. Inclusion criteria were age less than 18 years and a minimum of 1 year radiographic follow-up. Statistical methods included Fisher's exact test with significant probability values being defined as less than 0.05.

Results: We identified 121 angulation-only patients and 41 completely displaced patients that met the criteria to be included in our study. All fractures were treated nonsurgically. We identified a significantly higher ($P = 0.008$) refracture rate (18%, 22 of 121) in angulation-only fractures as compared to 0% (0 of 41) for completely displaced fractures. Subgroup analysis of the angulation-only fractures revealed that fractures angulated less than 40° refractured at a 26% rate (18 of 69) versus 8% (4 of 52) of fractures with greater angulation ($P = 0.009$).

Conclusion: We found that angulation-only shaft fractures had a significantly higher refracture rate than completely displaced fractures. Subgroup analysis demonstrated that less angulated fractures had a higher refracture rate than the more angulated ones. We feel this somewhat paradoxical finding is analogous to greenstick fractures of the forearm shaft that refracture at a higher rate than complete forearm shaft fractures due to less exuberant callus formation.

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Predicting Redisplacements of Diaphyseal Forearm Fractures: How About the Three-Point Index?

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Background/Purpose: Redisplacement is the most common complication during the cast treatment of forearm diaphyseal fractures in children. It would seem to be worth making an effort to apply the three-point index (TPI) to diaphyseal forearm fractures, as it has previously been found to most accurately predict redisplacement in the distal radius. The index is based on the three-point fixation principle in the cast treatment. The aim of this prospective study was to determine the effect of cast-related indices and other factors that could play a role in redisplacement.

Methods: 76 children were included. Age, initial complete displacement, reduction quality, location of the fracture, having fractures at different levels, and quality of the casting (according to TPI, cast index, Canterbury index, padding index) of each patient were analyzed as possible risk factors. Logistic regression analysis was utilized to search for risk factors.

Results: A total of 18 of 76 fractures were redisplaced in the cast. A TPI value higher than 0.8 was the only significant risk factor for redisplacement at 239 times more likely to redisplace (P <0.001; odds ratio: 238.5; 95% confidence interval: 7.063-8054.86) than those with lower values. The TPI was far superior to other cast-related indices with a sensitivity of 84% and a specificity of 97%.

Conclusion: A cast lacking adequate three-point fixation is the major risk factor for a forthcoming redisplacement of a diaphyseal forearm fracture of the children.

See pages 91 - 132 for financial disclosure information.

Factors Associated With Nonunion in 97 Consecutive Type 2 and Type 3 Odontoid Fractures in Elderly Patients

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Purpose: Odontoid fractures are the most common cervical spine injury in older adults and have high rates of morbidity and mortality. The purpose of this study was to determine factors that were associated with nonunion in odontoid fractures.

Methods: Between 2002 and 2011, 97 consecutive patients, age 65 years and over, with type 2 and type 3 odontoid fractures were treated at a single Level I trauma center, were followed in a single private practice, and retrospectively evaluated. Radiographs were reviewed and fusion was determined by flexion/extension x-rays, CT scan, or both. 23 mortalities occurred prior to 6 months postinjury, and they were excluded from the fusion analysis. One patient was lost to follow-up prior to evaluation for fusion.

Results: There were 31 males (42%) and 42 females with a mean age of 80 (range, 65-93) who were evaluated for fusion of their type 2 (55, 75%) or 3 (18, 25%) odontoid fracture. Mean body mass index (BMI) was 26.9 (range, 17.1-37.5). The overall fusion rate in the 73 patients who were living at the time of fusion analysis was 71.2%. Patients treated with nonsurgical management had a lower rate of fusion (31 of 51, 60.8%) compared to patients who were treated with surgery (21 of 22, 95.5%) ($\chi^2 = 0.003$). Males had a lower fusion rate (18 of 31, 58.1%) than females (34 of 42, 81%) ($\chi^2 = 0.033$). Fusion was affected by comorbidities. Those with fusion had a lower Charlson score (1.65) than those who did not fuse (2.67) ($t = -2.045$, sig = 0.045). Additionally, congestive heart failure (CHF) was a significant independent medical comorbidity associated with nonunion. Out of the 21 patients who were found to have nonunion, 8 (38.1%) had a diagnosis of CHF at the time of admission. 52 patients were found to have a fusion of their odontoid fracture, and only 4 of those patients had CHF (7.7%) ($\chi^2 = 0.002$). Factors without statistical significance included age, BMI, tobacco use, sagittal fracture displacement, direction of displacement, type of odontoid fracture, odontoid angle, time to surgery, method of nonsurgical management, time to discontinuation of rigid collar, and surgical technique.

Conclusion: Factors associated with nonunion in older patients with odontoid fractures include: nonsurgical treatment, males, higher numbers of medical comorbidities, and congestive heart failure.

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CASE PRESENTATIONS

Surgical Treatment of Pediatric Femur Fractures,
Current Concepts
Moderator: *Enes Kanlic, MD, PhD*
Faculty: *Amr A. Abdelgawad, MD; J. Eric Gordon, MD* and *Marc F. Swiontkowski, MD*

Management of Pelvic and Acetabulum Fractures
Moderator: *Paul Tornetta, III, MD*
Faculty: *Thomas F. Higgins, MD; Robert V. O'Toole, MD* and *Philip R. Wolinsky, MD*

The Isolated Humerus: Not All Belong in the Sarmiento
Moderator: *Lisa K. Cannada, MD*
Faculty: *Clifford B. Jones, MD* and *William T. Obremskey, MD, MPH*

NOTES

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SKILLS LABS

ORIF Distal Radius Fractures *(#SL6)*
Lab Leader: *Melvin P. Rosenwasser, MD*
Faculty: *Gregory DeSilva, MD; Michael D. McKee, MD; Matthew D. Putnam, MD; Saqib Rehman, MD* and *Thomas F. Varecka, MD*

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SYMPOSIUM III: THE OPERATIVE VERSUS NON-OPERATIVE TREATMENT OF COMMON UPPER EXTREMITY INJURIES: WHAT DOES EVIDENCE-BASED MEDICINE TELL US?

Moderator: *Michael D. McKee, MD*

Faculty: *Peter A. Cole, MD*
Clifford B. Jones, MD
Stephane Pelet, MD, PhD
Melvin P. Rosenwasser, MD
Emil H. Schemitsch, MD

8:00 am	**Introduction** *Michael D. McKee, MD*
8:05 am	**Fractures of the Clavicle** *Michael D. McKee, MD*
8:15 am	**Fractures of the Scapula** *Peter A. Cole, MD*
8:25 am	**Fractures of the Proximal Humerus** *Clifford B. Jones, MD*
8:35 am	**Acute Acromioclavicular Dislocations** *Stephane Pelet, MD, PhD*
8:45 am	**Fractures of the Humeral Shaft** *Emil H. Schemitsch, MD*
8:55 am	**Fractures of the Radial Head** *Michael D. McKee, MD*
9:05 am	**Fractures of the Distal Radius** *Melvin P. Rosenwasser, MD*
9:15 am	**Cases, Questions and Discussion** *All Faculty*

NOTES

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MINI SYMPOSIA

What Could Go Wrong Did: Getting Out of Trouble
Moderator: *Lisa K. Cannada, MD*
Faculty: *Frank Liporace, MD; Brian H. Mullis, MD* and *David C. Templeman, MD*

Geriatric Pelvis and Acetabular Fractures:
We Should Treat Them Like Hip Fractures
Moderator: *Brett D. Crist, MD*
Faculty: *Michael T. Archdeacon, MD; Cory A. Collinge, MD;*
Steven A. Olson, MD and *Stephen A. Sems, MD*

Malunion / Nonunion Management: What I Wish Someone
Had Told Me Before I Started Doing These Cases
Moderator: *Samir Mehta, MD*
Faculty: *David P. Barei, MD; Gregory J. Della Rocca, MD, PhD* and *J. Spence Reid, MD*

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Δ Open Reduction and Internal Fixation Compared With Primary Subtalar Fusion for Treatment of Sanders Type IV Calcaneal Fractures: A Randomized Multicenter Clinical Trial

*Canadian Orthopaedic Trauma Society; **Richard E. Buckley, MD**;*
University of Calgary, Calgary, Alberta, Canada

Purpose: There is controversy regarding the surgical treatment of Sanders type IV displaced intra-articular calcaneal fractures (AO-OTA Fracture and Dislocation Compendium, Foot Fracture Classification: 82-C4). The purpose of this study was to determine whether treating Sanders type IV calcaneal fractures with open reduction and internal fixation (ORIF) as compared with primary subtalar fusion (PSF) results in better long-term health outcomes.

Methods: Five surgeons at four Level I trauma centers across Canada participated. Patients were randomized to receive either ORIF or PSF. A standard protocol, involving a lateral approach for ORIF or distraction bone block arthrodesis, was used for the surgical procedures. This protocol arose from surgeons and their experience with a previous large calcaneal operative trial. Health outcomes were assessed with four validated instruments: (1) the Short Form-36 version 2 (SF-36), (2) the Musculoskeletal Function Assessment Survey (MFA), (3) the American Orthopaedic Foot & Ankle Society's Ankle-Hindfoot Scale (AHS), and (4) the visual analog scale (VAS). Follow-up was for a minimum of 2-7 years.

Results: From 2004 to 2011, 31 patients with 31 fractures were included in the study. 17 patients received ORIF; 14 received PSF. The two groups had no difference in demographics (severity of fracture, age, gender, smoking, and Workers' Compensation Board status). 26 patients were followed and assessed for a minimum of 2 years and a maximum of 7 years (84% follow-up). Five patients were lost to follow-up. For each health outcome, we report the mean score with standard deviation (SD) for both surgical treatments and the P value. No statistically significant difference was found between the results for ORIF compared with PSF: the mean SF-36 physical component scores were 30.2 (SD 11.4) and 37.8 (SD 10.4), respectively ($P = 0.10$); the mean MFA scores were 44.2 (SD 25.6) and 37.9 (SD 21.5), respectively ($P = 0.50$); the mean AHS scores were 62.5 (SD 19.6) and 65.8 (SD 19.2), respectively ($P = 0.68$); and the mean VAS scores were 36.8 (SD 34.7) and 33.9 (SD 30.7), respectively ($P = 0.82$).

Conclusion: We did not find a difference between treating Sanders type IV fractures with ORIF compared with PSF. Either of the two treatment modalities may be optimal for this fracture. It remains the choice of the surgeon and patient to take into account patient specific factors to determine treatment.

Funding: This clinical trial received funding from the OTA.

Δ OTA Grant

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Combined Approaches Increase Nonunion in Tibial Pilon Fractures

Paul M. Balthrop, MD[1]; *Daniel S. Chan, MD*[1]; *Brian White, MD, David Glassman, MD*[2]; *Roy Sanders, MD*[1];
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[2]*Naval Medical Center, Portsmouth, Virginia, USA*

Background/Purpose: Staged fixation of tibial pilon fractures has become commonplace. There is very little literature, however, discussing the staged fixation of the tibia through separate incisions. Recent evidence has suggested that a staged approach to the posterior tibia may offer improved articular reductions at the time of anterior fixation. To date, no large series of patients with staged posterior fixation has been compared with isolated anterior fixation to determine if this improvement in reduction holds true.

Methods: From January 1, 2005 to December 31, 2011, all records of patients treated for 43C fractures of the distal tibia were reviewed. Patients in this retrospective clinical cohort were grouped according to posterior-anterior and anterior-alone approaches. Medical charts and surgical documentation were reviewed and postoperative CT scans were examined for residual articular displacement and quantified. Ultimate union rate was correlated with approach strategy. Articular reduction was subdivided into three groups (<1 mm, 1-2 mm, >2 mm).

Results: 116 patients were identified as having had 43C fractures treated surgically with postoperative CT scans completed. 26 fractures presented as an open injury. Of these 116 patients, 35 underwent staged fixation of the posterior malleolus at an average of 10 days postinjury, followed by delayed anterior fixation at an average of 16 days postinjury. The remaining 81 patients underwent anterior fixation alone. 21 patients were lost to follow-up prior to 6 months. Of the 95 patients with sufficient follow-up, there were 24 nonunions. There was a statistically significant association of nonunion with staged posterior approach (40% vs 19%, $P = 0.015$). CT reduction for staged-posterior versus anterior-alone approach was not significantly different for any of the three categories (63% vs 57% <1 mm, 31% vs 26% 1-2 mm, 6% vs 17% >2 mm).

Conclusion: There is no statistically proven benefit to combined surgical approaches to tibial pilon fractures. It appears from this investigation that there is a significantly higher risk of nonunion with no demonstrable benefit to articular reduction. While articular reduction is of paramount importance, aggressive approaches to direct reduction and fixation of all fragments may lead to further complications.

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Long-Term Follow-up of High-Energy Pilon Fractures:
A Prospective Comparison of Locked Plates Versus Nonlocked Plates

*Theodore T. Le, MD; **Albert d'Heurle, MD**; Namdar Kazemi, MD;*
Michael T. Archdeacon, MD, MSE; John D. Wyrick, MD;
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Purpose: This study was undertaken to compare the clinical and radiographic outcomes of patients treated with either locking plates or conventional nonlocking plates in the management of high-energy pilon fractures. Our null hypothesis is that there would be no significant difference in the incidence of loss of reduction or functional outcomes between nonlocked and locked plates in the treatment of high-energy pilon fractures.

Methods: A prospective treatment protocol on patients with high-energy pilon fractures treated at a Level I trauma center between December 2005 and December 2008 was established and followed. Patients were randomized to either locking or nonlocking devices according to their medical record number. Radiographic outcomes were assessed with at least 6-month follow-up. Mortise/AP and lateral radiographs of the ankle were evaluated at the latest follow-up to assess for loss of reduction compared to radiographs at the time of surgery. This was defined as an angle measurement change ≥5°. Ankle hindfoot scores and Short Musculoskeletal Function Assessment (SMFA) functional outcome scores were collected on all patients with at least 1-year follow-up.

Results: From December 2005 through December 2008, 58 patients were randomized to receiving either a locked or a nonlocked plate for the treatment of high-energy pilon fractures. Radiographic measurements at a minimum of 6 months were available for 34 fractures (33 patients). There were 19 fractures in Group Nonlock and 15 in Group Lock. The average follow up was 30.6 ± 15.7 months (range, 8-67). Fracture classification included 25 OTA 43-C3, five 43-C2, two 43-C1, and two 43-B3 fractures. Mechanisms of injury included 11 falls from a height greater than 10 feet, 12 falls from standing, 7 motor vehicle accidents, and 3 other injuries. On the mortise view, 2 of 15 (13%) fractures in Group Nonlock demonstrated loss of reduction >5° compared to 3 of 19 (16%) in Group Lock ($P = 0.999$). There were no soft-tissue complications that required surgical intervention. In terms of complications, Group Lock had 1 patient with a deep infection, 2 nonunions, and 2 hardware failures. Group Nonlock had 1 hardware failure and 1 infected nonunion. Functional outcome scores were available for 18 patients (31%), 8 patients in Group Lock and 10 in Group Nonlock, with an average follow-up of 35.6 ± 16.0 months (range, 13-67). There was no significant difference between the ankle hindfoot scores (Lock: 71.75 ± 71.75; Nonlock: 66.1 ± 23.8; $P = 0.625$), the SMFA-BI (bother index) scores (Lock: 7175 ± 25.4; Nonlock: 66.1±23.8; $P = 0.625$), or the SMFA-FI (function index) scores (Lock: 32.9 ±36.2; Nonlock: 25.7 ± 20.2; $P = 0.587$).

Conclusion: The staged protocol for the treatment of high-energy pilon fractures has overcome the soft-tissue complications previously encountered. However, our data demonstrated that locking constructs have not improved the overall outcome of high-energy pilon fractures in terms of maintaining reduction or functional outcomes. However, given the low incidence of reduction lost in this study, the possibility of a type II error must be considered.

See pages 91 - 132 for financial disclosure information.

Δ Early Weight Bearing and Mobilization Versus Non–Weight Bearing and Immobilization After Open Reduction and Internal Fixation of Unstable Ankle Fractures: A Randomized Controlled Trial

***Niloofar Dehghan, MD**[1]; Richard Jenkinson, MD[2]; Michael McKee, MD[1]; Emil H. Schemitsch, MD[1]; Aaron Nauth, MD[1]; Jeremy Hall, FRCSC[1]; David Stephen, MD[2]; Hans J. Kreder, MD[2];*
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Background/Purpose: The optimal postoperative protocol with respect to weight bearing and ankle range of motion (ROM) following surgical fixation of acute ankle fractures remains elusive. Convention dictates non–weight bearing and immobilization for 6 weeks postoperatively, but early weight bearing may expedite return to function (with the potential risk of loss of fixation or wound complications). Our goal was to conduct a randomized controlled trial comparing early weight bearing and mobilization versus non–weight bearing and immobilization after surgical fixation of unstable ankle fractures.

Methods: We conducted a multicenter randomized controlled trial at two Level I trauma centers. Patients who underwent acute surgical fixation of an unstable ankle fracture were recruited and randomized to one of two rehabilitation protocols: (1) early weight bearing (weight bearing and ankle mobilization at 2 weeks) or (2) delayed weight bearing (non–weight bearing and casting for 6 weeks). Patients with posterior malleolar fixation or syndesmosis injuries were excluded. Patients were seen in follow-up at 2 weeks, 6 weeks, 3 months, 6 months, and 12 months postoperatively. The primary outcome was rate of return to work; secondary outcomes included ankle ROM, SF-36 (Short Form-36) heath outcome scores, Olerud/Molander ankle function score, and rates of complications (wound complication, loss of reduction, hardware failure, reoperation).

Results: In total 110 patients were recruited: 56 were randomized to early weight bearing and 54 were randomized to the delayed weight-bearing group. Patients were 47% female, 53% male, with a mean age of 42 years; there were no differences between the two groups with regard to demographics, preinjury type of occupation, type of fracture, or time to surgery. There was no difference between the two groups with regards to rate of return to work at any time point. However, at 6 weeks postoperatively, patients in the early weight-bearing group had significantly improved ankle ROM (42° vs 28°, $P = 0.001$), significantly improved Olerud/Molander ankle function scores (44 vs 31, $P = 0.002$), as well as significantly improved SF-36 scores on both the physical (50 vs 42, $P = 0.008$) and mental (62 vs 54, $P = 0.005$) components. There were no cases of fixation failure, loss of reduction, or repeat operation in either group. There were also no differences with regards to wound complications or infections.

Conclusion: This randomized study of early versus delayed weight bearing demonstrated no significant difference with regard to rate of return to work in patients with surgically treated ankle fractures. However, patients treated with the early weight-bearing protocol had significantly improved ankle function, ankle ROM, and improved mental and physical

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health outcome scores early in the postoperative period. There were no failures of fixation or differences in wound complications between the two groups. Given the convenience for the patient, the early improved functional outcome, and the lack of an increased complication rate with early weight bearing, we recommend early postoperative mobilization and weight bearing in patients with surgically treated ankle fractures.

See pages 91 - 132 for financial disclosure information.

Does the Müller AO Classification System for Ankle Fractures Correlate More Closely to the Mechanism of Injury Than the Lauge-Hansen System?

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Purpose: This study was conducted to assess whether the Lauge-Hansen (LH) and the Müller AO classification systems for ankle fractures radiographically correlate consistently with real in vivo injuries as based on observed mechanism of injury.

Methods: Videos of potential study candidates sustaining ankle injuries were reviewed on YouTube.com and individuals were recruited for participation if the video was of sufficient quality to classify the injury mechanism and if the individual demonstrated sufficient trauma likely to have sustained an ankle fracture. Corresponding injury radiographs were obtained. Injury mechanism seen in the video clips was classified using the LH system as supination/external rotation (SER), supination/adduction (SAD), pronation/external rotation (PER), or pronation/abduction (PAB). Corresponding radiographs were classified by the LH system and the AO system.

Results: Of over 2500 video clips reviewed, 625 demonstrated an injury mechanism classifiable by the LH system with a likelihood of sustaining an ankle fracture and were invited to participate. Of the 116 responders, 30 injury videos with their corresponding radiographs were collected. Of the video clips reviewed, 16 had SAD deforming trauma and 14 had PER deforming trauma. There were 26 ankle fractures, 3 nonfractures and 1 subtalar dislocation. 12 fractures judged by video to be SAD injuries had corresponding SAD fracture patterns. Five PER video injuries had PER fracture patterns. Eight PER video injuries resulted in SER fracture patterns and one resulted in a SAD fracture pattern. When using the AO classification, all 12 SAD type injuries that resulted in a fracture resulted in 44A type fractures while the 14 PER injuries resulted in nine 44B fractures, two 44C fractures, and three 43A fractures.

Conclusion: When in vivo video injury clips of ankle fractures are matched to their corresponding radiographs, the LH system is 65% consistent in predicting fracture patterns from deforming injury mechanism. When using the AO classification system, overall consistency was 81%, as a PER mechanism appears to mostly result in 44B type fractures. The AO classification, despite its development as a purely radiographic system, appears to correlate with in vivo injuries more consistently than the LH system.

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The Quality and Utility of Routine Immediate Postoperative Radiographs Following Ankle Fracture Surgery

Elizabeth A. Martin, MD*; Sara Lyn Miniaci-Coxhead, MD; Joshua G. Hunter, MD; John T. Gorczyca, MD; Jonathan M. Gross, MD; Catherine A. Humphrey, MD; John P. Ketz, MD;*
University of Rochester Medical Center, Rochester, New York, USA

Background/Purpose: Patients who undergo open reduction and internal fixation of ankle fractures commonly undergo routine postoperative ankle imaging. As these patients are typically immobilized in splints or casts, postoperative ankle radiographs often provide limited visualization due to casting material and patient positioning. These radiographs confer additional radiation exposure to the patient and are a direct cost to the hospital and patient. The purpose of this study is to evaluate the utility and quality of routine immediate postoperative radiographs following ankle fracture surgery.

Methods: All ankle fractures undergoing open reduction and internal fixation at a single institution from January 1, 2011 to January 1, 2012 were reviewed. Immediate postoperative radiographs were evaluated using defined parameters to determine if three quality views (AP, lateral, and mortise) were obtained. The quality of the postoperative images was compared to that of saved intraoperative fluoroscopic images. Postoperative complications were evaluated in terms of fracture displacement, hardware malpositioning, and need for return to the operating room. A cost analysis was performed to determine the overall cost of postoperative radiographs.

Results: A total of 203 patients with 205 ankle fractures underwent surgical fixation, with 136 patients undergoing routine postoperative radiographs. Only 18 patients (13.2%) had three quality postoperative views of the ankle with the mortise (52.8%) and lateral (65.9%) views commonly performed with poor technique. No postoperative series offered improved visualization of the fracture compared with saved intraoperative fluoroscopic images. None of the patients without radiographs had a complication that could have been detected earlier using postoperative radiographs. Only one patient (0.49%) had displacement identified on postoperative films not seen on intraoperative images. This patient experienced increasing pain following marginal fixation and did not require return to the operating room. No fracture malalignment or hardware malposition was seen that was not visualized retrospectively on fluoroscopic images. No patients required return to the operating room based on immediate postoperative films. Postoperative radiographs increased the total cost by $191.00 per patient.

Conclusion: The routine use of immediate postoperative radiographs following ankle fracture surgery does not provide additional value to the patient or orthopaedic surgeon. The quality of these images is generally inferior to those obtained and saved intraoperatively due to malrotation and overlying cast material. To reduce cost and radiation exposure, immediate postoperative radiographs should only be obtained following intraoperative fluoroscopy in specific circumstances, such as increasing postoperative pain, marginal fixation, or instability.

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A Prospective Randomized Multicentric Trial Comparing a Static Implant to a Dynamic Implant in the Surgical Treatment of Acute Ankle Syndesmosis Rupture

Mélissa Laflamme, MD[1]; Etienne L. Belzile, MD[1]; Luc Bédard, MD[1];
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Purpose: Syndesmosis rupture is involved in 13% of ankle fractures and requires surgical stablilization. The recent trend toward dynamic fixation with an Endobutton is not yet supported by clinical randomized trials. The purpose of this study is to compare the functional outcome after stabilization of an acute syndesmosis rupture with either a static implant (a 3.5-mm metallic screw through four cortices) or a dynamic device (TightRope, Arthrex).

Methods: We conducted a randomized double-blind controlled trial involving 70 subjects (in five centers) with an acute syndesmosis rupture, stabilized either with a TightRope (n = 34) or a quadricortical screw (n = 36). The two groups were similar regarding demographic, social and surgical data. Main outcome was Olerud-Molander score at 6 months. A 1-year follow-up included (at 3, 6, and 12 months) functional status (Olerud-Molander, AOFAS [American Orthopaedic Foot & Ankle Society] ankle-hindfoot score, time to activities, ankle range of motion) and radiological evaluation (loss of reduction, implant failure). Reoperations and complications were recorded.

Results: Subjects with dynamic fixation achieved significantly higher performances as described with the Olerud-Molander scores at 3 (68.8 vs 60.2, P <0.05), 6 (84.2 vs 76.8, P <0.05), and 12 months (93.3 vs 87.6, P <0.05). We also observed better AOFAS scores at 3 (78.6 vs 70.6, P <0.05), 6 (87.1 vs 83.8, P = 0.13), and 12 months (93.1 vs 89.9, P = 0.13). Plantar flexion was superior with dynamic fixation at all times. Implant failure was higher in the screw group (36.1% vs 0%, P <0.05). Loss of reduction was observed in 4 cases in the static screw group (11.1% vs 0%, P = 0.06). Reoperation for any cause was more frequent in the screw group (33.3% vs 5.9%, P <0.05). We could not demonstrate major differences in the activity level between the two groups, except that subjects with dynamic fixation returned earlier to their previous sporting activities.

Conclusion: Dynamic fixation of acute ankle syndesmosis rupture with the TightRope gives better functional outcomes at short and intermediate terms. The implant offers adequate syndesmosis stabilization without breakage or loss of reduction and reoperation rate is significantly lower than with the conventional screw fixation.

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The Fate of the Fixed Syndesmosis Over Time

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Background/Purpose: A prior study demonstrated statistical widening of the syndesmosis within weeks of elective screw removal. However, no information is available as to the radiographic outcomes of screw retention. The purpose of this study is to evaluate syndesmotic widening and talar shift over time in patients treated with syndesmotic screws and to compare removal versus retention along with other potential risk factors that may lead to syndesmotic widening over time.

Methods: A consecutive series of patients with ankle fractures and associated syndesmotic disruption treated with open reduction and internal fixation (ORIF) were reviewed. Demographic data, fracture classification, fixation, syndesmotic screw outcomes (removal, loosening/breakage, or retained and solid), and radiographic findings (MCS = medial clear space, CS = tibia-fibula space, and OL =tibia-fibula overlap) on the mortise and AP radiographs were evaluated at presentation, immediately postoperative, and final follow-up at a median of 6 months. Screw removal was offered to patients and performed at 12 weeks if chosen. *T* tests were used to compare postoperative and final follow-up measurements as well as groups of interest.

Results: 166 patients (94 men and 72 women) aged 16 to 83 years (average = 39.9) treated operatively for syndesmotic disruption comprise the study population. There were 84 SE (supination external rotation), 54 PE (pronation external rotation), and 28 PA (pronation abduction) injuries. 39 (23%) presented with dislocation. 123 were treated with a plate and syndesmotic screws and 43 with syndesmosis-only fixation. Postoperative radiographic alignment was not affected by fracture type, presence of initial dislocation, or use of a plate. 58 (35%) of the patients had their screws removed by choice, and at final follow-up 17 (16%) of the remaining patients' screws were solid and 91 (84%) were loose or broken. The following table details the measurements for all patients:

All Patients	Tibia-Fibula CS			Tibia-Fibula OL			Tibiotalar MCS		
	Preop	**Postop**	**Final**	**Preop**	**Postop**	**Final**	**Preop**	**Postop**	**Final**
AP	6.24	3.66	4.05*	4.78	6.89	7.35	4.24	2.31	2.05
Mortise	7.46	3.76	4.24*	–0.41	3.29	3.02	4.73	2.19	2.21

*Significance with *P* <0.05.

There was an approximately 0.5-mm shift in the fibula over time compared to the postoperative radiograph (AP, *P* =0.02; mortise, *P* = 0.003) without any change in MCS, indicating that the mortise remained intact without talar shift. We compared those whose screws were removed versus retained, screws removed grouped with those that were loose/broken versus solid and retained, those who presented dislocated versus not, fixed with a plate versus screws only, and Weber B versus C injuries on the AP and mortise views for all measure-

ments. The only significant finding was a slightly greater CS (4.6 mm vs 4.1 mm, P = 0.02) and lower OL (2.4 mm vs 3.3 mm, P = 0.03) on the mortise view for those whose screws were removed by choice as compared with those whose screws were retained, regardless of loosening or breakage. These differences were only 0.5 mm and 1.1 mm, and did not reach statistical significance after adjusting for multiple evaluations (reset of P <0.005 Bonferroni correction).

Conclusion: In contradistinction to prior work, we found only very mild widening (0.5 mm) of the tibia-fibula space occurs over time after syndesmotic fixation. Removal of syndesmotic screws at 3 months results in slightly less OL (~1 mm) and greater CS (0.5 mm) than screw retention even if the retained screws loosened or broke, but this was not associated with any talar subluxation. These differences were not statistically significant, and were quite small (<1 mm). The mortise in patients remains intact regardless of whether the syndesmotic screws are removed, loosen or break, or remain solid and in place.

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Does Syndesmotic Injury Have a Negative Effect on Functional Outcomes? A Multicenter Prospective Evaluation

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Background/Purpose: A negative prognosis has been reported for indirect ankle fractures with associated syndesmotic disruption as compared to those without syndesmotic injury. However, no report has separated Weber C from B injuries as a confounding variable. Ideally, this factor should be eliminated from the analysis to truly understand the effect of syndesmotic injury. Our purpose was to evaluate the effect of syndesmotic disruption on the functional outcomes of Weber B, SE4 (supination external rotation) ankle fractures treated surgically.

Methods: We performed a prospective multicenter evaluation of 242 patients (136 women, 106 men) with Weber B SE4 ankle fractures treated surgically. The average age was 46 years (range, 18-83). 81 (35%) of these patients had intraoperatively confirmed syndesmotic instability after fibular fixation and were reduced and fixed with syndesmotic screws. Outcomes evaluated at 6 weeks and 3, 6, 9, and 12 months included Short Musculoskeletal Function Assessment (SMFA), Bother Index, and American Orthopaedic Foot & Ankle Society (AOFAS) scores as well as symptomatic hardware and peroneal tendon discomfort. Statistical analysis was done using a mixed linear regression analysis using adjusted means with Tukey's method to account for repeated measures by a PhD statistician for functional outcomes to evaluate the recovery curve of the two groups, and for gender and race. *T* tests and χ^2 were used for other variables at the final 1-year outcomes.

Results: The adjusted means regression analyses demonstrated that patients without a syndesmotic injury had better SMFA scores at 12 weeks ($P = 0.02$), but not at 6, 26, or 52 weeks ($P = 0.76$, 0.73, 0.32). No syndesmotic injury also resulted in statistically better scores for the AOFAS ($P = 0.0006$) and trended toward better results for the Bother Index ($P = 0.07$). Men had better results than women for all outcomes: SMFA ($P = 0.002$), Bother Index ($P = 0.008$), and AOFAS ($P = 0.0006$). Race was not a significant factor for any score. Isolated analysis of the 1-year results revealed a difference in the SMFA and Bother Index, but not the AOFAS (Table). At 9 to 12 months, hardware was symptomatic in 17% of patients with and 10% of those without syndesmotic fixation ($P = 0.28$), and peroneal symptoms present in 14% and 8%, respectively ($P = 0.24$).

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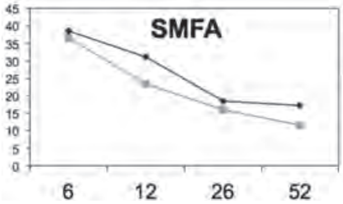
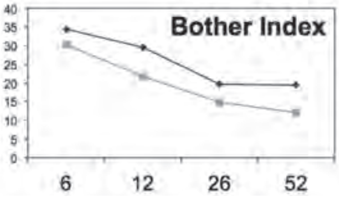
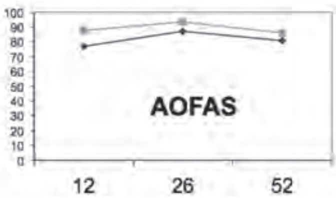
Table 1: One-Year Results

Group	SMFA	Bother	AOFAS
Syndesmosis injury	17.19	19.36	80.58
No syndesmotic injury	11.60	12.06	85.89
P value	0.04	0.05	0.21







Conclusion: Syndesmotic instability in association with Weber B, SE4 ankle fractures had worse outcomes at 1 year using the SMFA and bother indices. The difference was at the limit of clinical significance (1/2 standard deviation). Additionally, mixed linear regression over time demonstrated better results for the SMFA (only at 6 weeks) and the AOFAS with the Bother Index just outside of statistical significance. The most consistent finding, however, was better outcomes for men for all measures at all time points. Syndesmotic injury has a slightly detrimental effect on outcomes of surgically treated Weber B SE4 fractures.

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Stress Ankle Radiographs and Predictability of Deep Deltoid Ligament Injury in a Supination–External Rotation Cohort

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Background/Purpose: Stress ankle radiographs are commonly performed to determine deltoid ligament integrity in patients with a supination–external rotation (SER) pattern ankle fracture. Recognition of a medial-sided injury in this cohort is important as this fracture pattern is considered unstable and it has been shown that these patients benefit from surgical stabilization. However, there is variability in the literature as to what constitutes a positive stress ankle radiograph and to date only cadaver studies have examined the sensitivity and specificity of differing medial clear space (MCS) measurements. The purpose of our study was to compare the injury and stress radiographs of SER-pattern ankle fractures with or without a deep deltoid ligament injury and determine the predictive ability of the MCS in identifying a deltoid ligament tear.

Methods: All patients with an SER-pattern fibula fracture without a medial malleolus fracture from 2006 to 2012 were identified from the senior surgeon's prospectively collected ankle fracture database. Only patients with injury ankle radiographs, an external rotation stress radiograph, and an ankle MRI scan within 1 week of the injury were included for analysis. All stress radiographs were performed in the emergency department by an on-call orthopaedic resident. MCS was measured using our institution's picture archiving and communication system (PACS) and represented the distance from the medial aspect of the talus horizontally to the articular surface of the medial malleolus at the talar dome. This distance was measured and recorded for both the non-stress and stress ankle mortise radiographs. The integrity of the deep deltoid ligament was by two independent and blinded fellowship-trained attending musculoskeletal radiologists based on the ankle MRI.

Results: 52 patients were eligible for analysis. The average patient age was 47.5 years and 53.8% (28 of 52) were male. Of the 52 patients, 50% (26) had no MRI evidence of a deep deltoid ligament rupture and therefore were classified as an SER II or SER III injury. The other 50% (26 of 52) were classified as SER IV equivalent injuries due to MRI evidence of a high-grade deep deltoid ligament tear. SER II/III patients demonstrated an average MCS distance of 4.34 mm during stress radiographs. The SER IV cohort's average MCS was 5.81 mm when the ankle was stressed. Comparison of the average MCS measurements between the two groups was significantly different (P <0.001). Finally, an absolute MCS on stress radiograph of greater than 5.0 mm had a calculated 65.4% sensitivity and 76.9% specificity for identifying a deep deltoid ligament tear. The corresponding positive and negative predictive values were 73.9% and 69.0%, respectively.

Conclusion: External rotation stress ankle radiographs are a common method for determining deltoid ligament integrity in patients with an SER ankle fracture. We have shown that stress radiographs are able to accurately distinguish between patients with or without a deep deltoid ligament injury based on the extent of MCS widening. We also found that a stress view MCS measurement greater than 5.0 mm had a 65.4% sensitivity and 76.9% specificity for identifying a deep deltoid ligament tear.

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Anatomical Fixation of Supination–External Rotation Type IV Equivalent Ankle Fractures

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Background/Purpose: Ankle fracture fixation continues to challenge orthopaedists despite the plethora of research into novel fixation strategies. Outcomes vary with these novel strategies, but discrepancies continue to exist regarding the most successful means of fixation. We have previously published our fracture-specific treatment strategy for supination–external rotation (SER) ankle fractures, which has exhibited equivalent outcomes between boney and ligamentous injuries as well as between geriatric and nongeriatric populations. These results have been contrary to previously published literature and previously held dogma. The goal of this study is to extend that anatomical treatment strategy to supination type IV equivalent (SER IV E) ligamentous injuries and compare our previous patients with our current strategy of deltoid and posterior inferior tibiofibular ligament (PITFL) repair. We hypothesize that our radiographic and functional outcomes will be improved with the addition of ligamentous repair.

Methods: This is an IRB-approved evaluation of a prospectively collected database of a single surgeon from a Level I trauma center. All MRI-confirmed SER IV E (45 patients) ankle fractures treated between 2004 and 2011 with at least 1-year clinical follow-up were included in this cohort. Prior to 2010 all SER IV E ankle fractures were treated with lateral malleolus fixation and transsyndesmotic screws in the setting of a positive intraoperative stress test. Since 2010 all SER IV E ankle fractures have undergone PITFL fixation with a soft-tissue washer and 3.5-mm cortical screw followed by an intraoperative stress test. Deltoid ligament repair with a medial malleolus or talus suture anchor was reserved for intraoperative stress showing increased talar tilt or increased medial clear space (MCS). All patients underwent immediate postoperative bilateral CT scans to evaluate articular reduction and syndesmotic reduction. Postoperative radiographs measuring tibiofibular clear space (TCS) and MCS were performed. Change in TCS or MCS >2 mm from initial radiographs was considered a loss of reduction. Greater than 2 mm difference in anterior or posterior syndesmotic width when compared to the uninjured side was considered a syndesmotic malreduction. Functional outcome scores as measured by the Foot and Ankle Outcome Score (FAOS) were compared for patients with at least 1-year functional outcome score follow-up.

Results: There was no significant difference in mean postoperative TCS, MCS, or change in TCS or MCS between the cohorts. The anatomical treatment group had significantly better postoperative syndesmotic reduction compared to the nonanatomical cohort (7.4% vs 21.4%; $P = 0.02$). The mean difference in syndesmotic width for the nonanatomical cohort was 1.8 mm compared to 0.9 mm in the anatomical cohort. All transsyndemostic screws were removed at 4 months in the nonanatomical cohort (14 patients). The nonanatomical cohort had slightly better dorsiflexion of ankle (mean 19° vs 17°; $P = 0.02$). The nonanatomical group had significantly better functional outcome scores in all categories of the FAOS outcomes

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score (quality of life, return to sports, activities of daily living, pain, and symptoms) despite worse syndesmotic reduction.

Conclusion: This comparison of treatment strategies for SER IV E ankle fractures has shown an improvement in immediate postoperative syndesmotic reduction and the elimination of reoperation for removal of transsyndesmotic screws, but this does not translate to improved functional outcomes in this cohort. While short-term outcomes (1 year) appear worse, longer-term investigation of these patients is necessary to determine the impact of the anatomical treatment strategy on posttraumatic osteoarthritis and poorer future outcomes.

PAPER ABSTRACTS

See pages 91 - 132 for financial disclosure information.

MINI SYMPOSIA

Management of Pediatric Trauma Urgencies / Emergencies
Moderator: *David A. Podeszwa, MD*
Faculty: *Christine A. Ho, MD; Anthony I. Riccio, MD* and *Robert L. Wimberly, MD*

Rib Fracture Fixation in 2013:
Lunatic Fringe or State of the Art?
Moderator: *Michael D. McKee, MD*
Faculty: *Peter Althausen MD; Niloofar Dehghan, MD; Morad Hameed, MD; Aaron Nauth, MD; Emil H. Schemitsch, MD* and *Gerard P. Slobogean, MD*

Orthopaedic Surgeons Taking Ownership of Extremity Trauma:
Soft Tissue Coverage
Moderator: *Christopher M. McAndrew, MD*
Faculty: *Martin I. Boyer, MD; Duretti Fufa, MD; Daniel A. Osei, MD;* and *David A. Volgas, MD*

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Utilizing the ASA Score as a Predictor of 90-Day Perioperative Readmission in Patients With Isolated Orthopaedic Trauma Injuries

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Background/Purpose: As the American health-care system moves toward new payment structures that will no longer reimburse hospitals for perioperative readmission, it is critical that the orthopaedic trauma surgeon develop tools to predict the risk of postoperative readmission. While many studies have investigated readmission in the geriatric hip fracture population, very few studies have explored factors influencing postoperative hospital readmission in the orthopaedic trauma population. The American Society of Anesthesiologists (ASA) physical status classification is used worldwide by anesthesia providers as an assessment of the preoperative physical status of patients. This study seeks to explore factors influencing the readmission of patients with orthopaedic trauma injuries and the potential utilization of the ASA score in predicting a patient's risk of readmission.

Methods: All orthopaedic trauma patients who presented to a large Level I trauma center for operative treatment of their fracture from January 1, 2005 to December 31, 2010 were identified using CPT code searches and the institution's orthopaedic database. A total of 7338 unique patients were identified. The charts of these patients were reviewed to identify isolated cases in which there was only a single fracture requiring operative fixation with no other organ injury. 2354 patients fit this strict criterion. Of these patients, 1819 had complete readmission information and were included for analysis. The ASA scores of these patients who had isolated orthopaedic injuries were obtained from the institution's perioperative warehouse. The electronic medical records of these patients were then reviewed for basic demographic information such as age, gender, race, and medical comorbidities (coronary artery disease, diabetes, etc); the date of the first readmission related to the primary orthopaedic trauma fracture; and the reason for readmission. Patients were grouped into the following readmission categories: postoperative infection, postoperative surgical revision, and nonoperative medical condition. A logistic regression controlling for age, gender, race, 21 individual medical comorbidities, and type of fracture was conducted to identify the predictive ability of ASA on the likelihood of readmission for patients with isolated orthopaedic trauma injuries.

Results: Of the 1819 patients with strictly isolated fractures, 216 had acetabular fractures, 1252 had isolated lower extremity fractures, and 351 had isolated upper extremity fractures. After controlling for age, gender, race, medical comorbidities, and type of fracture for these patients, ASA had a significant association with 90-day readmissions ($P = 0.036$). Compared to patients with an ASA score of 1, patients with an ASA score of 2 were 1.21 times as likely to have a readmission; patients with an ASA score of 3 were 1.46 times as likely to have a readmission; and patients with an ASA score of 4 were 1.77 times as likely to have a readmission.

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Conclusion: The ASA score is highly correlated with postoperative readmission rates for patients presenting with isolated orthopaedic trauma fractures. As such, the ASA score could potentially provide a powerful tool to help hospitals target "at risk" individuals in order to reduce the number of 90-day readmissions.

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Do Surgeons Know the Cost of Orthopaedic Trauma Implants? A Multicenter Study of 503 Surgeons

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William Cross, MD[5]*, Grant Garrigues, MD*[6]*; Mitchel B. Harris, MD*[7]*;*
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Background/Purpose: Implant costs represent a substantial portion of health-care expenditures, and orthopaedic surgeons are positioned to play a key role in controlling these costs. A knowledge of implant costs is essential in this process; however, it is unknown if orthopaedic surgeons are knowledgeable in this domain. The purpose of this study was to assess orthopaedic surgeons' knowledge of common orthopaedic trauma implant costs. Our hypothesis was that orthopaedic surgeons would demonstrate a low level of implant cost knowledge.

Methods: This IRB-approved study was designed as an online survey administered to attending orthopaedic surgeons and residents at 7 academic medical centers associated with trauma centers. The survey consisted of 10 common orthopaedic trauma implant constructs that were each identified with a radiograph as well as an itemized component list. At each institution, the most commonly used vendors were chosen to maximize surgeon familiarity with the implant constructs. The actual cost of each construct (defined as the contracted amount paid to the vendor by the institution) was determined at each institution and then compared with the respondents' estimates. Estimates that were as discrepant as ±20% of the actual cost were considered correct.

Results: The response rate for the survey was 96% (503 of 522). Overall knowledge of implant costs among attending orthopaedic surgeons was low (mean 20% correct, 95% confidence interval [CI] 18%-22%). Attending orthopaedic trauma surgeons demonstrated greater implant cost knowledge than nontrauma surgeons in the univariate analysis ($P = 0.007$), but this relationship was no longer significant after controlling for frequency of implant usage and other factors ($P = 0.23$). In the multivariate analysis, the factors significantly associated with attending cost knowledge were number of years in practice ($P = 0.03$), frequency of implant usage ($P = 0.009$), and the price of the implant construct itself ($P < 0.001$). Knowledge of implant costs was also low among residents (mean 16% correct, 95% CI 15%-18%, $P = 0.004$ compared to the attending surgeons). In the multivariate analysis, factors significantly associated with resident cost knowledge were frequency of implant usage ($P = 0.01$) and the cost of the implant construct itself ($P < 0.001$). Self-assessment of implant cost knowledge was low among attending surgeons as well as residents, with 27% rating it as poor, 31% as below average, 35% as average, 6% as above average and 0.4% as excellent. However, over

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80% of respondents indicated that cost should be “moderately,” “very,” or “extremely” important in the selection of orthopaedic trauma implants.

Conclusion: In this multicenter survey of 503 orthopaedic surgeons that captured 96% of potential respondents, most believed that cost should play an important role in the selection of orthopaedic implants. However, actual knowledge of implant costs was found to be low among attending surgeons as well as residents. If surgeons are expected to select lower cost implants when medically appropriate, additional education may be required to allow for this possibility.

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Does Fracture Care Make Money for the Hospital?
An Analysis of Hospital Revenue and Cost for Treatment of Common Fractures
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R Adams Cowley Shock Trauma Center, Department of Orthopaedic Surgery,
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Purpose: With increasing health-care costs and decreasing revenue, understanding the profitability of orthopaedic trauma care is becoming progressively more important. The relative profitability of caring for patients with various fractures is unknown, however. The purpose of this study was to determine the relative profitability to the hospital for a selection of specific common fractures.

Methods: Data were collected from hospital medical and financial records at a single large academic urban trauma center with a state-regulated hospital reimbursement system. This state's unique legislatively mandated system ensures that the burden of uncompensated care to the hospital is addressed and that cost-shifting from the uninsured to the insured patients is normalized across all payers. Hospital medical and financial records of 1020 patients admitted from 2008 to 2012 with a principal diagnosis of an acute traumatic fracture requiring surgical treatment were reviewed. Patients whose principal diagnosis fit into 1 of 5 common anatomic categories based on their ICD-9-CM codes were included. 275 acetabular fractures, 65 pelvis fractures, 277 hip fractures, 255 femoral shaft fractures, and 148 tibia shaft fractures were identified. Patients that sustained one of these fractures but had a different principal diagnosis were excluded. The net revenue, total cost of inpatient care (direct variable expense plus direct fixed expense), and direct margin (net revenue minus total cost, ie, profit) for each patient's acute inpatient hospital course were collected. Margins were compared using a one-way analysis of variance.

Results: The overall mean direct margin (profitability) of the cohort was $19,526 per patient. The overall mean revenue was $44,326 per patient and the overall mean cost of inpatient care was $24,812 per patient ($16,526 mean direct variable expense and $8,286 mean direct fixed expense). Factors most influencing cost included of length of stay ($6403, 26%) and operating room use ($6354, 26%). In addition, the supply variable expense (eg, orthopaedic implants) averaged $4169 (17% of total cost). Of 1020 patients, only 44 (4%) had a negative direct margin (indicating a net loss to the hospital). The most profitable diagnosis was pelvis fracture (P <0.05). Table 1 demonstrates cost and margin analysis for each fracture.

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Table 1 Cost and Margin Analysis (in US$)

	Net Revenue	Cost of Inpatient Care[a]	Direct Margin (Profit)	Supply Variable Expense (%)[b]
Pelvis	58,982	37,215	21,767	5,224 (14)
Acetabulum	48,197	28,737	19,460	4,051 (14)
Hip	39,619	20,103	19,579	3,743 (19)
Femur	41,360	21,862	19,498	4,619 (21)
Tibia	33,470	16,145	17,325	3,915 (24)

[a]Direct variable + direct fixed expenses. [b]eg, orthopaedic implants, percent of total cost.

Conclusions: This rate-regulated system allows analysis of hospital profitability in the context of a normalized revenue stream that should approximate the overall fiscal realities of other states. Our data show that providing orthopaedic trauma care can be economically feasible and even profitable to a hospital. Understanding the relative costs and margins will help providers and hospitals target cost containment projects.

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Sleep Disturbance Following Fracture Is Related to Emotional Well-Being Rather Than Functional Result

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Background/Purpose: Sleep disturbance is an extremely common complaint following orthopaedic trauma. However, the incidence, severity, and duration of sleep difficulty following common orthopaedic trauma surgeries are unknown. The aim of our study was to investigate the incidence and longitudinal improvement of sleep disturbance following four common orthopaedic traumatic conditions.

Methods: We reviewed prospectively collected functional outcomes data for 1095 orthopaedic trauma patients following four common orthopaedic trauma conditions. The functional status of patients with proximal humerus fractures (n = 111), distal radius fractures (n = 440), tibial plateau fractures (n = 109), and ankle fractures (n = 435) were followed with standard functional outcome measures. Surveys were conducted at 3, 6, and 12 months postoperatively. Patient-reported sleep disturbance, acquired from validated functional outcome surveys, was compared to overall functional outcomes scores and demographic information. Subgroup analysis was conducted for age, gender, body mass index, mechanism of injury (high versus low energy), and presence of additional fractures.

Results:

Percentage of Postoperative Sleep Disturbance at Standard Follow-up Intervals				
	Initial/Baseline	3 months	6 months	12 months
Proximal humerus fracture	Not recorded	41%	24%	18%
Distal radius fracture	7%	25%	16%	8%
Tibial plateau fracture	3%	32%	22%	18%
Ankle fracture	8%	19%	11%	11%

At 12-month follow-up the Short Form-36 Mental Health category for patients with distal radius fractures ($P = 0.001$) and the Short Musculoskeletal Function Assessment (SMFA) Emotional category for patients with tibial plateau fractures ($P = 0.024$) and ankle fractures ($P \leq 0.001$) were independent predictors of poor sleep while the respective functional status categories were not.

Conclusion: At 12-month follow-up, poor sleep was independently associated with poor emotional status, but not associated with poor functional status. The mental health status of patients with sleep difficulty in the latter stages of fracture healing should be carefully assessed in order to provide the highest level of care. The results of this study should allow orthopaedic trauma surgeons to counsel patients regarding expectations of difficulty sleeping following acute fractures.

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Anxiety and Depression in the Etiology of Chronic Pain: Results from a Two-Year Cohort Study of Trauma Patients

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Background/Purpose: Millions of Americans experience chronic pain. While chronic pain can often be linked to prior trauma, the risk factors for persistence following acute pain have just recently begun to receive attention. Numerous studies have shown that both acute and chronic pain increase risk for depression and anxiety, and a causal relationship has been hypothesized. The purpose of this study is to describe a structural model to explain the temporal relationships between pain, anxiety, and depression.

Methods: Patients (N = 545) from a longitudinal study of severe lower extremity trauma were followed at baseline, 3, 6, 12, and 24 months postinjury using a visual analog pain scale and the depression and anxiety scales of the Brief Symptom Inventory. Structural equation modeling (SEM) techniques were used to study temporal relationships between these three sets of longitudinal variables, presented as standardized regression weights (SRW). Multiple imputation techniques were used to account for missing data.

Results: A single structural model that included pain intensity, anxiety, and depression at all four time points yielded model fit measures indicating an excellent fit. Pain had weak effects on depression during the first year postinjury (3-6 months SRW = 0.07, P = 0.05; 6-12 months SRW = 0.06, P = 0.10), but did not predict depression beyond a year. Similarly, pain had weak effects on anxiety during the first year postinjury (3-6 months SRW = 0.05, P = 0.21; 6-12 months SRW = 0.08, P = 0.03). Depression did not predict pain over any of the time periods. In contrast, anxiety predicted pain over all three time periods, and the standardized regression weights for these relationships nearly doubled over this time span (3-6 months SRW = 0.11, P = 0.012; 6-12 months SRW = 0.14, P = 0.0065; 12-24 months SRW = 0.18, P <0.0001). These effects were independent of the effects of each parameter measured at the previous time point (eg, pain at 3 months predicting pain at 6 months).

Conclusion: The results support the hypothesis that in the early phase following trauma, pain elicits anxiety and depression. These effects are smaller, however, than the effect of anxiety on pain over this time period. In the late (or chronic) phase, the effect of anxiety on pain nearly doubles, and is the only causal effect observed. These results provide further evidence that negative mood, specifically anxiety, has an etiological role in the persistence of acute pain.

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Δ Impact of Early Postoperative Pain on Outcomes One Year Following Traumatic Orthopaedic Injury

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Purpose: The purpose of this study was to determine whether the level of pain at hospital discharge predicts physical and mental health, depression, and posttraumatic stress disorder (PTSD) at 1 year following traumatic orthopaedic injury. The hypothesis was that increased pain at discharge would predict decreased physical and mental health and increased depressive and PTSD symptoms after controlling for patient and injury characteristics.

Methods: This study prospectively enrolled 225 patients, 19 to 86 years of age, admitted to a Level I trauma center for surgical treatment of a traumatic lower extremity (87%) or upper extremity (13%) orthopaedic injury. Participants were enrolled postoperatively on the orthopaedic unit and answered questions on demographics. A discharge assessment measured pain intensity (Brief Pain Inventory [BPI]). A follow-up assessment 1 year after hospitalization measured physical and mental health (Short Form-12) and depressive and PTSD symptoms (Patient Health Questionnniare-9 [PHQ-9] and PTSD Checklist-Civilian Version [PCL-C], respectively). Clinical characteristics were abstracted from the medical record. At 1 year, 132 patients (59%) completed follow-up. Multiple imputation techniques were employed for patients lost to follow-up. However, 12 patients with both missing discharge and follow-up data were excluded from the final analysis. Separate multivariable linear regression analyses (N = 213) were performed to determine whether pain at hospital discharge predicted the outcomes of physical and mental health and depressive and PTSD symptoms, after controlling for age, gender, race, marital status, education level, employment status, and ISS. The level of significance was set at $\alpha = 0.05$.

Results: Average pain intensity scores at hospital discharge on the BPI were 6.3 (standard deviation [SD], 2.4). 28% of patients reported mild pain (BPI <5), 28% moderate pain (5 ≤BPI <7), and 44% severe pain (BPI ≥7). Separate multivariable regression analyses showed that increased pain at discharge predicted decreased mental health ($\beta = -0.91$; $P = 0.02$), increased depressive symptoms ($\beta = 0.58$; p= 0.03), and increased PTSD symptoms ($\beta = 1.6$; $P = 0.01$) at 1-year follow-up. In addition, having greater than a high school education predicted increased mental health ($\beta = 5.6$; $P = 0.01$) and decreased depressive ($\beta = -2.7$; $P = 0.01$) and PTSD symptoms ($\beta = -7.2$; $P = 0.01$). Pain at hospital discharge was not found to be a statistically significant predictor of physical health at 1-year follow-up.

Conclusion: Results imply that efforts to improve pain assessment and management among hospitalized orthopaedic trauma patients are needed to improve long-term mental health outcomes. Early screening for unmanaged pain is encouraged in order to identify patients at high risk for poor outcomes and who could benefit from more aggressive pain management.

Δ OTA Grant

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Nature's Wrath: The Effect of Daily Weather Patterns on Postoperative Pain Following Orthopaedic Trauma

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Background/Purpose: The effect of weather on patients' pain and mobility is a frequent complaint in all aspects of musculoskeletal care. While there has been limited investigation into the effects of weather on arthritis and various medical pathologies, to our knowledge there are no data regarding weather's effect on orthopaedic trauma patients' complaints of pain following acute and chronic fracture. The aim of our study was to investigate the influence of daily weather conditions on patient-reported pain and functional status.

Methods: We examined 2369 separate outpatient visits of patients recovering from operative management of an acute tibial plateau fracture (n = 332), an acute distal radius fracture (n = 1179), or chronic fracture nonunion (n = 858). At each outpatient visit, patients were asked to report their pain on a scale of 0 to 10. Functional status was recorded using the DASH (Disabilities of the Arm, Shoulder and Hand) or SMFA (Short Musculoskeletal Function Assessment). For each individual patient visit date, we then recorded the mean temperature, difference between the mean temperature and expected temperature based on a 17-year average, dew point, mean humidity, amount of rain, amount of snow, barometric pressure, and wind speed. All weather data were specific to the zip code of the outpatient medical office where patients were seen, and obtained from a publicly available almanac. Statistical analysis was run to search for correlations between weather data and patient-reported pain scores and functional status.

Results: There was a highly significant association between low barometric pressure (calculated as below one standard atmosphere or 29.92 in) and increased pain for patients at 1-year follow-up only ($P = 0.006$), and a trend toward association between low barometric pressure and increased pain for all patient visits ($P = 0.072$). At 1-year follow-up, temperatures above 35°F ($P = 0.018$) and humidity above 70% ($P = 0.001$) were also significantly associated with increased pain. No other weather data had significant correlation with patient-reported pain scores. No significant association was noted between weather data and patient-reported functional status (as calculated by the DASH or SMFA functional indexes).

Conclusion: While pain in the immediate postoperative period is most likely dominated by incisional and soft-tissue injuries, as time progresses weather clearly impacts patient pain levels. Variation in patient-reported pain scores due to weather conditions should be anticipated. Patients may be counseled that their symptoms may worsen in association with weather conditions.

PAPER ABSTRACTS

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Health Literacy in an Orthopaedic Trauma Population:
Improving Patient Comprehension Reduces Readmission Rates

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Background/Purpose: Research has demonstrated that surgical patients often have problems comprehending and/or identifying their discharge instructions, medications, and the specifics of their diagnoses. Patients with lower educational backgrounds have worse comprehension than those with higher educational backgrounds. It is reasonable to assume that lack of comprehension among orthopaedic trauma patients may have a deleterious effect on postoperative complication rates leading to unnecessary hospital readmissions. This study sought to determine if an educational tool administered at discharge designed to improve patient comprehension reduced the rate of unplanned readmissions secondary to postoperative complications.

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 the bone fractured, the type of implanted fixation, weight-bearing status, expected recovery time, and deep venous thrombosis (DVT) prophylaxis. All patients received verbal and written instructions outlining this information at hospital discharge. During the second half of the study, patients received an intervention consisting of an informational sheet with both text and pictorial representations at discharge that reinforced the aforementioned information. Patients with minimum 3-month follow-up were included to evaluate for hospital readmission secondary to surgical site infection, hardware failure, or DVT. Statistical analysis between the two patient populations—pre- and post-intervention—was conducted using Student *t* tests and χ^2 tests comparing demographic variables, performance on comprehension questionnaire, and hospital readmission rates.

Results: 299 eligible questionnaires were collected. 146 patients were given the standard discharge instructions (control group), while 153 patients were also administered the additional information sheet (intervention group). Previous work demonstrated that the intervention group had higher comprehension as indicated by their mean score on the questionnaire comprehension section ($P = 0.009$). Of the original 299 patients, 206 had minimum 3-month follow-up or suffered a postoperative complication (control group = 100, intervention group = 106). There was a 19% readmission rate secondary to postoperative complications in the pre-intervention group (N = 19/100), and a 9.4% readmission rate secondary to postoperative complications in the post-intervention group (N = 10/106). The readmission rate secondary to postoperative complication was statistically significantly lower in the post-intervention group (19.0% vs 9.4%, $P = 0.048$)

Conclusion: The use of an information sheet with text and pictorial representations to explain discharge instructions has been shown to improve patient comprehension. Furthermore, hospital readmission rates secondary to postoperative complication rates were decreased among patients who received the additional intervention.

See pages 91 - 132 for financial disclosure information.

Stress Hyperglycemia Is Associated With Surgical Site Infection: A Prospective Observational Study of Nondiabetic, Noncritically Ill Orthopaedic Trauma Patients

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Purpose: Multiple studies have demonstrated the detrimental effects of hyperglycemia in trauma patients; however, there is a paucity of data concerning hyperglycemia and nondiabetic orthopaedic patients. We conducted the present study to evaluate the relationship of hyperglycemia and surgical site infections in a cohort of nondiabetic, noncritically ill orthopaedic trauma patients.

Methods: This was a prospective observational pilot study over a 9-month period (February 2011-October 2011). Inclusion criteria were patients age >17 years admitted with orthopaedic injuries requiring surgical intervention. Patients with a history of diabetes mellitus, current corticosteroid use, multisystem injuries, or who were admitted to the ICU were excluded. Demographics, medical comorbidities (as classified by the American Society of Anesthesiologist physical status), body mass index (BMI), presence of an open fracture, and number of operations were recorded. Fingerstick blood glucose values were ordered twice daily for each patient. Hyperglycemia was documented for a fasting glucose value >125 mg/dL or a random value >200 mg/dL on more than one occasion, and was considered prior to the development of an infection. Hemoglobin A1C (Hgb A1C) was obtained from hyperglycemic patients, and occult diabetes was considered for an Hgb A1C >5.9. Occult diabetes mellitus was excluded from final study analysis. Surgical site infection was considered by a return trip to the operating room and confirmed by positive intraoperative cultures at the operative site.

Results: 171 patients were enrolled. Forty patients (23.4%) were hyperglycemic; 7 of these 40 (17.5%) had Hgb A1C >5.9. The final study population consisted of 164 patients, 33 (20.1%)with hyperglycemia. There were 12 (7.3%) surgical site infections. There was no significant association with age, gender, race, medical comorbidities, obesity (BMI >29), tobacco use, or the number of surgical procedures and the primary outcome. Patients with hyperglycemia were more likely to develop a surgical site infection (7 of 33 [21.2%] vs 5 of 131 [3.8%]; *P* = 0.001). Open fractures (6 Type I, 22 Type II, 22 Type III) were also associated with surgical site infections (7 of 50 [14%] vs 5 of 114 [4.4%]; *P* = 0.03). However, there was no association with open fractures and hyperglycemia (10 of 50 [20.0%] vs 23 of 114 [20.2%]; *P* = 0.98).

Conclusion: Hyperglycemia was present in 20% of nondiabetic orthopaedic trauma patients and demonstrated a significant association with surgical site infection in this prospective observational cohort. While many factors may contribute to surgical site infections, there is presently a lack of data on hyperglycemia in nondiabetic, noncritically ill patients. Future randomized studies are necessary to further determine the impact of glucose control on outcome in orthopaedic trauma.

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Effectiveness of Vitamin D Therapy in Orthopaedic Trauma Patients

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Purpose: 77% of our orthopaedic trauma patients have been shown to have either vitamin D deficiency or insufficiency. The purpose of this study was to determine the effectiveness of our vitamin D treatment protocol in orthopaedic trauma patients. Our hypothesis was that vitamin D therapy normalized serum vitamin D levels.

Methods: A retrospective review was done of all orthopaedic trauma patients at a university Level I trauma center from January 1, 2009 to September 30, 2010. Patients were selected if they had an initial and repeat vitamin D-25 serum levels. The standard regimen for all patients was over-the-counter vitamin D 1000 IU and 1500 mg of calcium daily. For patients with vitamin D deficiency or insufficiency, they also received 50,000 IU of ergocalciferol weekly until their vitamin D level normalized or their fracture healed. No compliance monitoring was performed except for questioning at each clinic visit.

Results: 201 patients had initial and repeat Vitamin D-25 levels. 84% of patients with a normal initial vitamin D-25 level remained normal and 16% became insufficient or deficient. 48% of the patients initially in the insufficient group improved to normal and 8% became deficient. Of the patients with vitamin D deficiency, 26% remained deficient and 74% became insufficient (see table).

Vitamin D-25 Level	Average Initial Vitamin D-25 Level (ng/mL)	Average Repeat Vitamin D-25 Level (ng/mL)	Average Increase in Vitamin D-25 Level (ng/mL)
Normal (≥32 ng/mL)	39.13	41.03	1.90
Insufficiency (<32 ng/mL) (insufficient group only)	25.19	33.98	8.79
Deficiency (<20 ng/mL)	13.74	28.67	14.93

Conclusion: Although Vitamin D therapy did improve the majority of the patients' vitamin D-25 level, it was not as successful as was hoped. Patients with initial deficiency had the largest improvement but still did not normalize. This study indicates that continued vigilance is required to adequately treat a low vitamin D-25 level. Future studies will prospectively evaluate treatment regimens and the effect of low vitamin D on complications of orthopaedic trauma.

See pages 91 - 132 for financial disclosure information.

Are Routine 2-Week Postoperative Radiographs Useful?

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Purpose: The purpose of this study is to evaluate the utility of early postoperative radiographs in the management of patients with surgically stabilized lower extremity fractures.

Methods: In a retrospective manner we collected 320 patients treated surgically for fractures involving the femur, tibia, and/or fibula by a single orthopaedic traumatologist. Routine practice at our facility is to follow up with surgery patients at approximately 2 weeks, 6 to 8 weeks, and 3 months postoperatively. If patients underwent staged management, then the 2-week follow point considered was after the final surgery. Medical records and radiographs were reviewed for all patients.

Results: Over a 5-year period, 320 patients with 344 fractures involving the femur, tibia, and/or fibula underwent surgical repair of their fracture. There were 162 men and 158 women. The average age was 42 years (range, 18-95 years). The average follow-up period for all 344 fractures was 110 days. Of the 344 fractures, 309 were radiographed at 2 weeks. There were 28 patients (35 fractures) who did not have 2-week radiographs secondary to being an inpatient or did not follow up at the 2-week interval. Of these 28 patients, none required any additional surgical interventions. Of the 309 fractures that had radiographs at 2 weeks, 246 fractures in 233 patients were followed for 3 months or greater duration. Four fractures required subsequent intervention at less than 3 months. All four interventions consisted of surgical irrigation and débridement of wound infections with removal of the exposed hardware. In our study no fracture required revision fixation as a result of the 2-week postoperative radiographs. In addition, no patient had a change in mobilization, weight bearing, or range of motion activities as the result of the 2-week radiographs.

Conclusion: The routine use of radiographic examination at the 2-week postoperative visit has limited utility.

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Nonoperative Treatment of Closed Extra-Articular Distal-Third Diaphyseal Fractures of the Humerus: A Comparison of Functional Bracing and Long Arm Casting

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Background/Purpose: Advocates of functional bracing for nonoperative treatment of distal-third diaphyseal humerus fractures are concerned that long arm casting may cause elbow stiffness, while advocates of long arm casting claim superior alignment. We performed a retrospective comparison of these two nonoperative treatment methods.

Methods: 105 consecutive patients with a closed, extra-articular fracture of the distal third of the humeral diaphysis were identified from two orthopaedic trauma databases between 2003 and 2011. 80 patients were followed until healing and near full motion, to surgery for nonunion, or at least 6 months otherwise. 51 patients managed with functional bracing and 24 patients managed with long arm casting had adequate follow-up. Elbow range of motion and radiographic alignment of the humerus at the last follow-up were compared between the two treatment groups using the Student *t* test.

Results: All of the fractures healed. The average arc of elbow flexion was 130° ± 9.4° in braced patients versus 127° ± 11.9° in casted patients ($P = 0.26$). Four (8%) patients in the bracing group and four (17%) in the casting group had lost >20° of elbow motion. The average varus-valgus angulation was 17° ± 7.8° versus 13° ± 8.4°, respectively ($P = 0.11$) and the average anterior-posterior angulation was 9° ± 6.2° versus 7° ± 7.5° ($P = 0.54$), respectively.

Conclusion: For closed extra-articular distal-third humeral fractures, both functional bracing and long arm casting have a 100% union rate and there are no differences in average elbow motion or radiographic alignment.

See pages 91 - 132 for financial disclosure information.

Functional Outcome Scores of Humeral Shaft Fractures in Patients Treated Nonoperatively Compared to Those Treated Surgically

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Purpose: Most studies of humeral shaft fractures report fracture angulation and shoulder range of motion, but not functional outcomes. This study used validated functional outcome measures to assess patients following nonoperative and surgical management of humeral shaft fractures. Our hypothesis is that patients treated surgically will have less disability and better shoulder function.

Methods: 240 patients treated between 2004 and 2011 were retrospectively identified with billing codes. Patients from this cohort were recruited by telephone to obtain the following functional outcome scores: Disabilities of the Arm, Shoulder and Hand (DASH), the Simple Shoulder Test (SST), and general health questionnaire Short Form-12 (SF-12). Patients were asked to rate their pain during the immediate 3-week period following surgery or splinting (scale 1-10), whether or not they would undergo the same treatment again, and if they were pleased with the cosmetic appearance of their arm. Patient chart reviews were conducted to obtain basic demographic data. Data were analyzed using two-tailed Student *T* tests, Mann-Whitney U test, or χ^2, and the data are present as the mean ± the standard error of the mean (SEM).

Results: 66 patients were recruited with complete data sets. Number of months from treatment rendered to interview date (surgical 44.6 ± 4.9 vs nonoperative 45.6 ± 5.7; $P = 0.89$) and average age (surgical 48.9 ± 3.2 vs nonoperative 43.5.8 ± 4.7; $P = 0.32$) did not differ between treatment groups. The DASH scores were higher in patients treated surgically (DASH 26.8 ± 3.7; n = 38) than in patients treated nonoperatively (DASH 12.9 ± 3.2; $P < 0.05$; n = 29). Average functional shoulder scores were lower in patients treated surgically (SST 8.00 ± 0.6) than in patients treated without surgery (SST 9.93 ± 0.5; $P < 0.05$). The SF-12 physical component summary (PCS) was higher in the nonoperative group (49.6 ± 2.3) compared to the surgical group (39.4 ± 1.3; $P < 0.05$). The mental component summary (MCS) did not differ between the groups (surgical MCS 51.8 ± 1.8; nonoperative MCS 53.2 ± 1.6; $P = 0.55$). 79% of surgical patients would undergo surgery again, while 66% of the nonoperative group would repeat the same treatment ($P = 0.19$). Self-reported pain scores in the 3 weeks following treatment were 5.9 ± 0.5 for surgery and 6.4 ± 0.4 for nonoperative treatment ($P = 0.51$). Of the patients surveyed, 73% of the surgical group were happy with the cosmetic appearance of the arm, and 66% were pleased in the nonoperative group ($P = 0.51$).

Conclusion: Patients with humeral shaft fractures that meet surgical criteria and undergo surgical fixation have less shoulder function, worse overall physical health, and more upper extremity disability compared to patients who can be managed nonoperatively. Both patient populations have similar mental health outcomes, posttreatment pain, and cosmetic appeal. The difference in outcomes suggests that humeral shaft fractures meeting surgical criteria are more severe and result in decreased long-term upper extremity function compared to injuries that do not meet these criteria.

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A Prospective Randomized Study of Operative Treatment for Noncomminuted, Humeral Shaft Fractures: Open Plating Versus Minimally Invasive Plate Osteosynthesis (MIPO)

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Purpose: This study was prospectively designed to compare the clinical and radiologic results for open plating and minimally invasive plate osteosynthesis (MIPO) in the treatment of simple-type humeral shaft fractures. The hypothesis was that the clinical result in the MIPO group would be the same or superior to that of the conventional plating group.

Methods: From June 2011 to Dec 2011, 68 patients presented to five Level I trauma centers. These patients were prospectively randomized into an open plating group (32 cases) and MIPO group (36 cases). All patients had average 15-month follow-up with minimum 12 months. Clinical outcome measurements included fracture healing time, operation time, radiation exposure time, intraoperative nerve injury, and elbow and shoulder function. Complications such as infection, nonunion, and malunion were also evaluated. Radiographic measurements included fracture alignment, time to healing, delayed union, and nonunion.

Results: 31 fractures (97%) in the open plating group were healed by 16 weeks versus 36 fractures (100%) in the MIPO group by 15 weeks ($P = 0.588$). Blood loss was 185 mL in open plating group and 102 mL in the MIPO group and it showed significant difference statistically ($P < 0.001$). Time of radiation exposure was 10 seconds in the open plating group and 68 seconds in the MIPO group ($P < 0.001$). There was no difference in operation time (116 minutes vs 105 minutes, $P = 0.106$) or complication rate. Both groups had excellent radiologic result and functional outcomes of the elbow and shoulder and there were no differences.

Conclusion: For patients requiring surgical treatment of a noncomminuted humeral shaft fracture, both open plating and MIPO both provide predictable results for achieving fracture healing with excellent elbow and shoulder function.

See pages 91 - 132 for financial disclosure information.

Upright Compared to Supine Radiographs of Clavicle Fractures: Does Patient Positioning Affect Displacement?

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Background/Purpose: Clavicle fracture displacement, as determined from plain radiographs, is an important criterion in treatment planning. Radiographs taken with the patient supine may yield different results compared to those taken with the patient upright. The null hypothesis was clavicle fracture displacement measured on supine radiographs would be similar to displacement measured on upright radiographs.

Methods: 43 patients (average age 47 ± 18 years, 31 male) with clavicle fractures (35 OTA 15B, and 8 OTA 15C) who had AP and 30° caudal clavicle radiographs taken in both supine and upright positions were studied. Using a picture archiving and communication system (PACS), vertical displacement and clavicle length were measured and compared between the supine and upright positions retrospectively. One resident and two fellowship-trained traumatologists classified the fractures and measured displacement and shortening. Data were aggregated and compared to ensure reliability with a two-way mixed interclass correlation coefficient (ICC).

Results: Vertical fracture displacement averaged 13.8 ± 11 mm in upright radiographs and 8.1 ± 8.1 mm in supine radiographs (*t* test, P <0.001), representing a 69% increase in fracture displacement with upright positioning. Injured clavicle length was 15.9 ± 2 cm in upright radiographs and 16.4 ± 1.8 cm in supine radiographs (*t* test, P <0.05), a 3% decrease. 15 of 43 patients (35%) had greater than 100% clavicle diameter displacement seen on upright, but not on supine, radiographs. The ICC was 0.82 (95% confidence interval [CI]: 0.7-0.9) for OTA fracture classification, 0.92 (95% CI: 0.86-0.95) for vertical displacement measurement, and 0.91 (95% CI: 0.81-0.95) for injured clavicle length, demonstrating very high agreement of fracture classification and measurement among evaluators.

Conclusion: Increased fracture displacement and shortening was observed in upright radiographs compared to supine radiographs when evaluating clavicle fractures. The null hypothesis was disproved. This suggests that upright radiographs may better estimate fracture energy and severity, and better predict the position at healing if nonoperative treatment is selected. Both upright and supine radiographs are recommended to accurately determine the extent of fracture motion. The addition of upright radiographs could have significant impact on operative indications for clavicle fixation.

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Can Complications of Locked Plating About the Proximal Humerus Fractures Be Minimized? The Effect of the Learning Curve

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Background/Purpose: We previously reported on early complications of proximal humerus fractures treated with locked plates. In 51 consecutive patients, we found a complication rate of 24%, the most common of which was screw penetration. Other recent studies have reported complication rates as high as 43% for proximal humerus fractures treated with locking plates. The purpose of this study was to reassess the incidence of complications following locking plate treatment of proximal humerus fractures (OTA Types 11) to determine if the effect of the learning curve could diminish these outcomes.

Methods: 163 consecutive patients with proximal humerus fractures were prospectively tracked following operative fracture fixation with a locking plate. All patients were treated between February 2003 and July 2012 at our institution, and received similar treatment of open reduction and internal fixation with a locked plate followed by early range of shoulder motion. The only difference in the surgical technique over time was a greater use of calcium phosphate cement as a bone void filler in more recently treated patients. Patient outcomes were assessed by radiographic examination and physical exam. All complications were recorded. Subgroup analysis for correlation with complication was performed for age, gender, body mass index, fracture type, mechanism of injury, and number of screws in the humeral head.

Results: Overall 30 of 163 patients (18%) had experienced a complication by the time of most recent follow-up (mean 16 months; range, 6-60 months). Of the 112 patients not included in our previous study, 18 patients (16%) developed 26 complications. Average fracture healing time was 3.7 months (range, 1.5-8 months). Only 6 of 112 patients (5%) had screw penetration, yet in our previous study 8 of 51 patients (16%) had screw penetration. The incidence of infection, hardware failure, and osteonecrosis remained low and largely unchanged. There was one intraoperative complication in the latter cohort.

Conclusions: As with most procedures, a learning curve with this procedure does appear to exist. The lower complication rate in our more recent patients suggests that complications reported in early locked plating series are not inherent to the implant or fracture. They can be diminished when surgeons and support teams frequently treat proximal humerus fractures, and/or employ new treatment strategies.

See pages 91 - 132 for financial disclosure information.

Minimally Displaced Radial Head/Neck Fractures (Mason Type I, OTA Types 21A2.2 and 21B2.1): Are We "Overtreating" Our Patients?

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Background/Purpose: Nondisplaced or minimally displaced radial head fractures (Mason Type I, OTA Types 21A2.2 and 21B2.1) are encountered frequently by orthopaedic surgeons following falls on outstretched arms. Although it is widely accepted that these fractures have excellent outcomes, there is no defined algorithm for the non-operative treatment radial head fractures. The aim of this study is to identify medical, radiographic, and demographic factors that predict full return to preinjury function for patients with Mason Type I radial head fractures treated nonoperatively.

Methods: We conducted a retrospective review of every patient who presented with a closed radial head/neck fracture seen at our tertiary care specialty institution in the past 2 years. A search of ICD-9 code 813.05, closed fracture of the radial head/neck, in our electronic record system yielded 82 consecutive patients with closed radial head/neck fractures. Initial injury radiographs were analyzed for fracture classification, displacement, size of effusion, and intra-articular fracture. Injury mechanism, additional injuries, and demographic information were recorded. For patients treated nonoperatively, follow-up intervals, physical exam scores, radiologic information, and physical therapy attendance were recorded for each outpatient visit. Statistical analysis of factors leading to full recovery was conducted.

Results: 54 patients (66%) were determined to have 56 nondisplaced or minimally displaced (2 mm or less) Mason Type I radial head fractures without additional injury to the affected limb. All patients in this cohort were treated nonoperatively and no patients in this cohort developed a complication or had any medical or surgical intervention other than physical therapy. Treating surgeons recommended a second outpatient follow-up visit with radiographs for 49 of 54 patients (91%), and of the patients who returned for a second follow-up, 16 of 27 (59%) were recommended to return for a third follow-up with radiographs. The average number of additional radiographs taken of the affected elbow after initial presentation was 4.4 (range, 0-12) for patients who returned for any follow-up. The presence of intra-articular fractures, 1 to 2 mm of displacement, and high-energy injury mechanisms was not significantly associated with recommendation for a second outpatient follow-up, third outpatient follow-up, or with the number of additional radiographs ordered beyond the initial exam. Pain with palpation of the radial head and range of motion deficits (both assessed at the second outpatient visit) were not associated with recommendation for a third outpatient follow-up or with the number of additional radiographs ordered beyond the initial exam.

Conclusion: In this study of patients with isolated, nondisplaced or minimally displaced radial head fractures, no patient developed a complication or needed subsequent surgery. Orthopaedic surgeons are likely overtreating patients with Mason Type I radial head fractures by recommending frequent follow-up without modifying treatment, leading to unnecessary patient visits, radiation exposure, and increased health-care costs.

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PROMIS Physical Function Computer-Adaptive Test Compared to Other Upper Extremity Outcome Measures in the Evaluation of Proximal Humerus Fractures in Patients Over 60 Years of Age

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Background/Purpose: In 2004 the National Institutes of Health funded PROMIS (Patient Reported Outcomes Measurement Information System) with the goal of creating highly reliable, precise measures of patient–reported health status. Key components of this effort were to use item response theory and computer-adaptive testing (CAT) to increase measure accuracy while decreasing patient burden. The effort has been very successful and several outcome measures have been created including ones for physical function. Although these measures have been studied in the general population and in some disease-specific populations, there has been little work evaluating them in orthopaedic trauma populations and they have not been compared to more commonly used, existing measures. The purpose of this study was to compare the PROMIS Physical Function (PF) CAT to commonly used traditional measures for the evaluation of patients with proximal humeral fractures. The traditional measures included the Disabilities of the Arm, Shoulder and Hand (DASH) measure, Short Musculoskeletal Functional Assessment (SMFA), and Constant shoulder score.

Methods: Patients over 60 years of age with displaced proximal humerus fractures treated either operatively or nonoperatively between 2006 and 2009 at two Level I trauma centers were identified and invited to participate in a study evaluating outcomes. 47 patients agreed to participate and returned for additional evaluation. Evaluation included completion of the DASH, SMFA, the PROMIS PF CAT, and the Constant shoulder score. All measures were administered electronically via an iPad accessing www.assessmentcenter.net, an online data management tool. Range of motion and strength measurement for the Constant shoulder score were collected by a research coordinator blinded to the treatment method. Descriptive statistics (eg, percentage, median, minimum, maximum) were obtained, and histograms were produced to review the distributional qualities of all continuous data. Pearson correlation analyses were then used to determine the observed correlations among the administered outcome measures.

Results: Of the 47 patients completing the study, 38.3% were male and 55.3% received surgical fixation. Median age at injury was 68.0 years (range, 60-88 years), while median time from injury to completion of outcome measures was 39.0 months (range, 17-77 months). On average, patients answered 86 outcome-related questions for this study: 4 for the PROMIS PF CAT (range, 4-8 questions), 6 for the Constant shoulder score, 30 for the DASH, and 46 for the SMFA. Time to complete the PROMIS PF CAT (median completion time = 98 seconds) was significantly less than that for the DASH (median completion time = 336 seconds, $P<0.001$) and the SMFA (median completion time = 482 seconds, $P<0.001$). Median completion time was not significantly different between the PROMIS PF CAT and the Constant shoulder score measures. PROMIS PF CAT scores correlated significantly with all other outcome measure scores. PROMIS PF CAT scores correlated highly with the DASH

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($r = -0.64$, $P < 0.001$), the SMFA Bother Index ($r = -0.71$, $P < 0.001$), the SMFA Functional Index ($r = -0.83$, $P < 0.001$) and the Constant-shoulder score ($r = 0.50$, $P < 0.001$). The SMFA displayed ceiling effects with 35% of patients scoring within 10 points of the maximum on both function and bother indices. Similarly, 23% of patient scored within 10 points of the maximum on the DASH.

Conclusion: The median completion time for the PROMIS PF CAT was less than one-third of that for the DASH and one-fifth of that for the SMFA. At the same time, it strongly correlated with these more commonly used upper extremity outcome measures, suggesting that it is measuring the same concept. This study suggests using the PROMIS PF CAT alone yields an assessment of upper extremity function similar to those provided by more commonly used measures while substantially reducing patient testing time.

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Pain Exposure Physical Therapy Versus Conventional Therapy in Patients With Complex Regional Pain Syndrome Type 1: A Randomized Controlled Trial

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Background/Purpose: More than half the patients with complex regional pain syndrome type 1 (CRPS-1) do not respond well to the current conventional evidence-based treatments and may progress to chronic disease with associated disabilities and restrictions in daily life. Nonrandomized studies have shown that a more comprehensive CRPS-1 treatment, Pain Exposure Physical Therapy (PEPT), is safe and possibly effective. The aim of this study is to determine whether PEPT is more effective than current conventional treatment regarding CRPS-related impairments, activities, and quality of life.

Methods: In a single-blinded randomized controlled trial, adult patients with CRPS-1 according to the "Budapest" criteria were recruited and randomized to receive either PEPT or conventional treatment. Primary outcome was the CRPS-1 Impairment level Sum Score (ISS). Secondary outcome measures were pain intensity, muscle strength, active joint range of motion, pain disability index, activity monitor, Tampa Scale for Kinesiophobia, and quality of life. Baseline measurements were performed before treatment and follow-up measurements were done at 3, 6, and 9 months after inclusion.

Results: Between January 2009 and June 2011, 58 patients were randomly assigned to either PEPT (n = 29) or conventional (CONV) (n = 29) treatment. The Impairment level Sum Score improved significantly more in the PEPT group compared to the CONV group as primary end point. The estimated group difference for ISS-RV for patients that did not switch after randomization was 3.22 (95% confidence interval [CI] –0.29, 6.72; P = 0.076). The estimated group difference for patients who switched after randomization was 3.79 (95% CI 0.83, 6.75; P = 0.013). The secondary end points visual analog scale (VAS) pain, pain disability index, and active joint range of motion improved significantly more in patients treated with PEPT compared to CONV. The estimated group difference for VAS pain, pain disability index, and active joint range of motion was, respectively, 18.39 (95% CI 4.28, 32.48; P =0.012), 9.59 (95% CI 1.87, 17.31; P = 0.017), and 8.22 (95% CI 2.38, 14.06; P = 0.007). The secondary end points muscle strength, activity monitor, and quality of life improved more in the PEPT group compared to CONV treatment but did not reach the level of significance. The improvement in kinesiophobia was equal in both groups. None of the patients reported serious side-effects or disease deterioration.

Conclusion: Pain Exposure Physical Therapy is a safe, nonpharmacological, and effective treatment of CRPS-1 and is superior to the current evidence-based conventional treatment.

Funding: Funds for this study were received from the Netherlands Organisation for Health Research and Development (ZonMW).

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When Do Distal Radius Fractures Most Likely Displace and When Do They Stop Moving: Long-Term Follow-up of Closed Reduction and Casting

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Background/Purpose: Distal radius fractures treated with closed reduction and casting lose position over a long time frame. Although most surgeons immobilize these fractures for 4 to 6 weeks, little data exist predicting when these fractures are most likely to lose reduction and when they ultimately stop moving. Our goal was to use a large data set of radiographic measurements, specifically volar tilt and radial height, for regression analysis in order to determine the change in these parameters over long-term follow-up.

Methods: We prospectively screened 546 consecutive distal radius fractures. We excluded patients with <10° of dorsal tilt upon presentation, leaving 275 fractures of which 168 were treated nonoperatively with closed reduction and casting. Patients were managed with short arm casts and seen every other week in the clinic by an attending orthopaedic trauma surgeon until 6 weeks and then at the discretion of the treating surgeon. Patients were re-casted if there was thought to be a shift in the fracture position or if the cast became loose. We excluded patients with less than 150 days of follow-up, measuring the radial height and volar tilt on initial injury film, postreduction, and all subsequent follow-ups in order to perform a regression analysis and place a best-fit curve for 96 measurements for each parameter. Based on this function, we calculated the number of days when 50%, 75%, and 95% of change occurred relative to 1 year, when full healing is presumed.

Results: Using regression analysis, we placed a best fit curve and determined the function for both radial height and volar tilt (Figures 1 and 2). Based on this function, we found a logarithmic curve in which 50% of the radial height is lost in approximately the first 30 days after reduction, 75% is lost in the first 82 days, and 95% is lost by day 278. Similarly, for volar tilt, 50% loss in reduction is seen in the first 18 days, 75% is lost in the first 81 days, and 95% is lost by day 263.

Discussion/Conclusion: Our goal was to use a large data set of radiographic measurements, specifically volar tilt and radial height, for regression analysis in order to determine the change in these parameters over longer-term follow-up. We found that 50% of the primary reduction parameters of radial height and volar tilt are lost in approximately the first 4 weeks after reduction, but loss continues to occur at a slower rate up until approximately 9 months. The majority of radial height and volar tilt are lost in the first 30 days after closed reduction and casting of distal radius fractures; however, the reduction continues to shift up to nearly 1 year. Because both loss of radial height and volar tilt have been implicated in long-term wrist dysfunction, these data are important in predicting both immediate and long-term radiographic outcomes of patients and may be important in early discussions regarding treatment.

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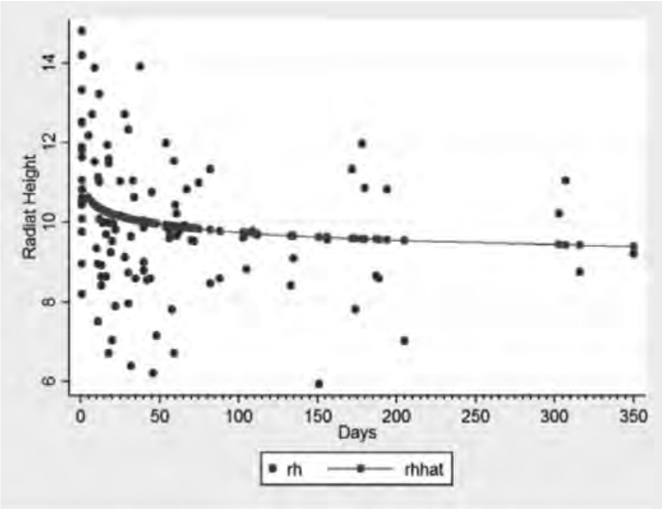
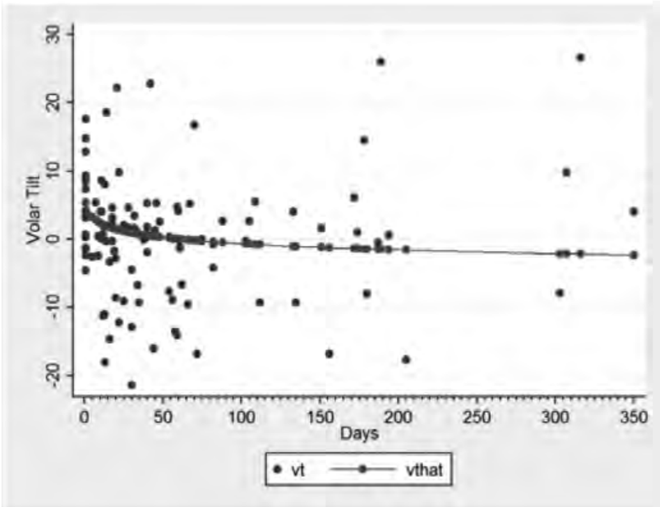


Figures 1 and 2: Best-fit regression curve and function for radial height and volar tilt. rh and vt: individual radial height and volar tilt measurements; rhhat and vthat: radial height and volar tilt function.

RHhat=11.0566–0.2837log(days) (P value = 0.0002)

VThat=5.3851–1.3131log(days) (P value = 0.0015)



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Quantification of Lateral Calcaneus Exposure Through the Extensile Lateral and Sinus Tarsi Approaches

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Purpose: The extensile lateral (EL) approach is a commonly used approach for open reduction and internal fixation of calcaneous fractures. However, the sinus tarsi (ST) approach has been proposed as a less invasive alternative to the extensile lateral approach for fixation of certain calcaneus fractures that may reduce wound complications and sural nerve injury. The primary purpose of this study was to evaluate the exposure of the posterior facet with the EL approach compared to the ST approach. We hypothesize that the ST approach will provide a similar exposure of the posterior calcaneal facet.

Methods: 16 sequential ST then EL approaches were performed. Calcaneal landmarks were identified by direct visualization or palpation: anterior process, middle facet, lateral calcaneal body, and posterior facet. The posterior facet was subdivided into the superomedial, superolateral, inferomedial and inferolateral corners for precise quantification. Calibrated digital photographs of the posterior facet and lateral calcaneal body were taken from standardized positions, and used to calculate the exposed surface area. Next, we attempted to place three different calcaneal plates (H plate, Y plate, and Wave plate) on the lateral calcaneus using each exposure. Finally, the horizontal distance from the distal-most aspect of the lateral malleolus to the sural and superficial peroneal nerves was measured.

Results: The average area of the posterior facet exposed with the ST approach was not significantly different than with the EL approach (331.3 mm^2 compared with 282.4 mm^2; $P = 0.432$). Significantly more of the lateral calcaneal body was seen with the EL approach (1894.8 mm^2 compared with 1192.2 mm^2; $P = 0.009$). Excluding the posterior facet superomedial corner, all of the landmarks evaluated were visualized in 100% of approaches. The superomedial corner could be visualized in significantly more of the cadavers with the EL approach (75% compared to 12.5%; $P = 0.0076$), and it could be palpated in one-eighth of the remaining cadavers in both approaches. The average horizontal distance from the distal aspect of the lateral malleolus to the superficial peroneal nerve was 3.49 ± 1.38 cm and 1.91 ± 0.32 cm to the sural nerve. Two plates (Y plate and Wave plate) fit appropriately on the lateral calcaneus in both exposures on all cadavers; one plate (H plate) fit in all EL approaches but only 12.5% of ST approaches.

Conclusion: The ST approach provides a similar amount of exposure of the posterior facet compared to the EL approach. However, use of the ST approach may limit fixation options, particularly the use of larger plates.

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Outcomes of Fasciocutaneous Flaps for Lower Extremity Trauma

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Purpose: This work was undertaken to report fracture healing, patient satisfaction, and functional outcome after fasciocutaneous flaps of the lower extremity in orthopaedic trauma patients.

Methods: 53 consecutive patients underwent fasciocutaneous flap coverage by a single orthopaedic trauma surgeon for wounds of the distal third of the leg after extremity trauma. 34 patients with 36 flaps were available for follow-up at 12 months and are the subject of this report. Subjects completed questionnaires at each clinic visit.

Results: There were 22 male and 12 female patients, with a mean age of 40.3 years (range, 22-64). The mean follow-up was 19 months. Fractures associated with the wound defect included distal-third tibia fractures (26), calcaneus fractures (8), and 2 had open wounds over the Achilles tendon. Indications for fasciocutaneous flap coverage included wound dehiscence (23), acute coverage of open fractures (9), and coverage after debridement for osteomyelitis (4). 27 patients (79%) were smokers. 32 flaps were reverse sural artery flaps and four were axial pattern flaps. Of the 4 patients with osteomyelitis, 1 ultimately required amputation and the other 3 resolved. No flaps required revision. One superficial wound infection was treated with oral antibiotics. All fractures healed within 12 months. Patients self-evaluated their flaps at each visit, using a subjective questionnaire.

	Good/Excellent	Fair/Poor
Swelling	50%	50%
Pain	47%	53%
Appearance	69%	31%
Ability to wear normal clothes	72%	28%
Ability to wear normal shoes	60%	40%

The mean Musculoskeletal Functional Assessment score was 43.6 (lower is better). The mean American Orthopaedic Foot & Ankle Society (AOFAS) score was 44 (range, 10-71) and the mean American College of Foot and Ankle Surgeons (ACFAS) score was 49 (range, 25-87).

Conclusion: The survival of fasciocutaneous flaps in lower extremity traumatic wounds is well documented in the plastic surgery literature. We have demonstrated that half of these patients complain of persistent swelling and pain, but more than half are generally pleased with their physical appearance and ability to wear normal clothes and shoes.

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Ankle Injury Pattern in a Maisonneuve Fracture Cohort: An MRI Study

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Background/Purpose: A Maisonneuve fracture is an uncommon variant of an external rotation ankle injury. The typical injury pattern consists of a proximal one-third spiral fibula fracture combined with a distal tibiofibular syndesmotic disruption and either a medial malleolus fracture or deltoid ligament tear. The fracture is believed to occur while the foot is in a pronated position at the time of injury, resulting in a Lauge-Hansen pronation–external rotation (PER) injury pattern. However, a recent case report documented a Maisonneuve fracture variant without MRI evidence of a medial-sided ankle injury, thereby raising the possibility of a non-PER mechanism. To our knowledge, only 1 study containing 5 patients has evaluated the ligamentous injury pattern using preoperative MRI for this particular fracture cohort. The primary purpose of this study was to document the pattern of osseous and ligamentous ankle injury and determine the incidence of Maisonneuve fracture patients without a medial-sided ankle injury.

Methods: Surgically treated Maisonneuve fractures were retrospectively identified from a single surgeon's log book from 2004-2012. Patients with a complete preoperative set of ankle and orthogonal tibia radiographs as well as preoperative ankle MRI were included for study. 21 patients met inclusion criteria. Preoperative radiographs were scrutinized for directionality of the proximal fibula fracture and pattern of osseous ankle injury. The preoperative MRI was evaluated by a blinded musculoskeletal-trained attending radiologist for evidence of injury to the anterior and posterior inferior tibiofibular ligaments (AITFL and PITFL) as well as the deep deltoid ligament. Preoperative and intraoperative stress radiographs and dictated operative reports were reviewed to corroborate the MRI findings.

Results: The average age of the 21 Maisonneuve fracture patients meeting criteria for this study was 44.3 years. 13 (61.9%) of the 21 patients were male. All 21 patients (100%) demonstrated MRI evidence of an AITFL tear. 20 patients (95.2%) had an injury to the posterior stabilizing structures of the ankle (ie, PITFL or posterior malleolus). 14 (70%) of these 20 patients had a posterior malleolus fracture and the remaining 30% (6 patients) had either a partial avulsion or complete tear of the PITFL. 3 (14.3%) of the 21 patients had no MRI evidence of a medial-sided ankle injury. However, stress radiographs and intraoperative findings later confirmed a missed deep deltoid ligament injury in one of these patients. Therefore, of the 19 total patients with a medial ankle injury, 47.4% (9 of 19) had a fracture of the medial malleolus and 52.6% (10) had a tear of the deep deltoid ligament.

Conclusion: Our results demonstrate that not all patients with a Maisonneuve fracture had evidence of a medial-sided ankle injury. This indicates that the fracture pattern cannot singularly be explained by a PER mechanism and we found that at least 9.5% of patients (2 of 21) sustained their injury via a supination–external rotation (SER) mechanism. Based on these findings, we recommend obtaining a stress ankle radiograph for all Maisonneuve fracture patients without obvious medial-sided ankle injury as a subset of these patients will not have a medial injury and may be best treated by nonsurgical means.

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•The Effects of Elevation, Simulated Injury and Immobilization on Muscle Perfusion: A Near-Infrared Spectroscopy Study in Humans

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Purpose: The goal of this study was to quantify the direct effects of elevation, simulated injury, and immobilization on muscle perfusion in the human leg using near-infrared spectroscopy. Muscle perfusion values of the lower limb at various degrees of elevation with and without simulated injury were measured and compared in 26 volunteers. As elevation increased, O_2 saturation decreased on average 0.06% per degree of elevation, demonstrating that elevation leads to compromised muscle perfusion.

Background: A common orthopaedic practice is to elevate a traumatized lower extremity with the goals of increasing venous and lymphatic drainage and reducing swelling. However, elevation may also compromise arterial inflow, resulting in what has been described as elevation ischemia. Therefore, the ideal degree of elevation for an injured lower extremity remains controversial.

Methods: 26 volunteers with no history of previous major lower limb injury or vascular disease were enrolled. Muscle perfusion in the anterior compartment of the right leg was measured at 0, 30, and 60 cm of elevation relative to the heart using a near-infrared spectroscopy unit. A standardized short-leg splint and a tourniquet inflated to 50 mm Hg were then applied to the left lower extremity to simulate injury as established in a previous experimental protocol and tissue perfusion measures were repeated. Muscle perfusion values at various degrees of elevation with and without simulated injury were then compared.

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Results: 18 males and 8 females between 22 and 62 years of age (mean 29.8 years) were enrolled. The mean regional O_2 saturation (rSO_2) of the anterior compartment of the control limb at 0° elevation was 74.2%. Mean rSO_2 of the simulated injury limb was reduced by 7.65%, which was statistically significant. Mean rSO_2 of the control limbs at 0, 30, and 60 cm of elevation was 74.2%, 72.5%, and 70.6%, respectively, while mean rSO_2 in the simulated injury group was 66.3%, 65.0%, and 63.3%. As elevation increased, O_2 saturation decreased on average 0.06% per degree of elevation, which was statistically significant.

Conclusion: Increasing levels of elevation in a human limb results in increasingly compromised muscle perfusion as measured by near infrared spectroscopy. This suggests that the clinical benefits of elevation such as edema control must be balanced against the deleterious effects of compromised perfusion. Ongoing research is indicated in patients with actual injuries to better characterize the effects of elevation on ischemia in the setting of lower extremity trauma.

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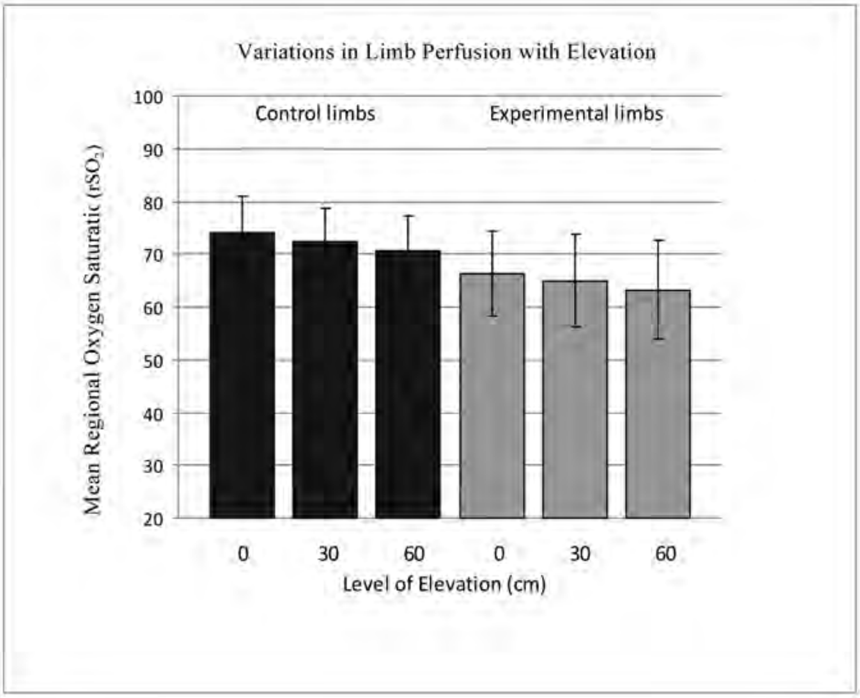

Figure 1.
Perfusion measurements of the control and simulated injury limbs at different levels of elevation.

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Predicting Successful Limb Salvage in Open Calcaneal Fractures Sustained During Recent Combat Operations: A Predictive Model using Patient- and Injury-Specific Variables

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Background/Purpose: Open calcaneus fractures are severe injuries causing substantial patient morbidity, often result in amputation, and present a significant challenge to the treating physician. A challenge exists in deciphering what patients can be successfully treated with limb salvage and who is likely to ultimately require and be best treated with an amputation. With this in mind, the goal of the study was to develop a predictive model, using data from open calcaneus fractures treated at our institution, which identify patient- and injury-specific variables to predict successful limb salvage.

Methods: Initial injury-specific data, inpatient treatment, and follow-up data were retrospectively collected from all patients with open calcaneus fractures who presented for limb salvage to our institution from 2003 through 2011. In an effort to design a prognostic model, we developed an artificial neural network (ANN) using the Oncogenomics Online ANN Analysis System designed to estimate the likelihood of eventual amputation, using information available during the initial débridements. We then performed 10-fold cross validation. Sensitivity and specificity were calculated using 50% estimated probability of eventual amputation.

Results: 155 open calcaneus fractures in were identified and analyzed during the 8-year study period. Mean patient age at time of injury was 26 years and average follow-up time was 3.6 years. 67% of calcaneus fractures were Gustilo-Anderson Type III injuries. Wound size averaged 26 cm^2, with 68% of wounds occurring on the plantar surface of the foot, and diminished or absent plantar sensation in 53%. 87 patients had maintained limb salvage at final follow-up, yielding an amputation rate of 44%. The neural network identified 8 features most associated with of eventual amputation and listed in order of importance are the following: higher American Society of Anesthesiologists grade, lack of plantar sensation, type of treatment prior to arrival at definitive care, increased fracture severity according to the Gustilo-Anderson and Sanders classifications, presence of a vascular injury, male sex, and a dismounted injury. These variables accurately estimated the likelihood of eventual amputation in the majority of cases. On internal validation, the area under the receiver operating characteristic curve was 0.83. Specificity was 92% and sensitivity was 48%.

Conclusion: Using an ANN and applicable clinical data, we successfully developed a prognostic model designed to predict the likelihood of eventual amputation in combat-wounded service members presenting with open calcaneus fractures. The results of this study have significant clinical implication for the treating surgeon and patient. This model, derived from known patient- and injury-specific characteristics, may be employed as a clinical decision support tool by helping to set patient and physician expectations, and guide surgical treatment decisions.

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Heel Pad Avulsion Injury: Classification and Role of Primary Topical Oxygen Therapy

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Background/Purpose: Heel pad avulsion is a common but poorly defined injury in terms of classification, prognosis, and management. The heel pad is a specialized soft-tissue structure for the purpose of weight bearing. Due to its precarious microvascular structure and lack of a standard treatment protocol, the prognosis of heel pad avulsions healing has been uniformly poor. Our purpose was to study the effect of primary topical oxygen therapy and to classify the heel pad avulsion injury for prognostication of its survival and chances of healing after repair. The functional outcome was assessed in terms of the ability of the patient to return to painless barefoot weight bearing.

Methods: 12 male patients between 4 and 50 years of age who sustained isolated heel pad avulsion injuries and presented to the emergency department within 6 hours were studied for patterns of heel pad avulsion injury and its management with an outcome assessment based on achievement of pain-free barefoot walking. Mode of injury was road traffic accident. The heel pad was avulsed in various patterns that were classified according to the intact hinge of the tissues, thickness of the avulsed soft tissues, and associated fractures. Primary wound lavage was followed by topical oxygen therapy for 90 minutes followed by definitive débridement and primary suturing of the heel pad with or without Kirschner wire fixation. Appropriate intravenous antibiotics and supportive therapy was also given. The heel pad was inspected for color change and status of wound margins every 12 hours and was given topical oxygen therapy for 90 minutes once in every 24 hours. Marginal skin necrosis in 4 cases healed uneventfully after re-débridement. Patients were permitted non–weight-bearing crutch mobilization at 2 weeks. Full weight bearing was permitted between 8 and 12 weeks depending upon individual injury pattern.

Results: The single outcome criterion was survival of the heel pad for painless barefoot weight bearing. Follow-up was from 6 months to 1 year. The heel pads survived in all 12 patients with minor complications in 4 cases. Heel pad avulsions that were earlier treated by us with débridement and intravenous antibiotics and fixation without primary topical oxygen therapy showed complete necrosis and infection within 48 to 72 hours, making the foot either unfit for weight bearing or requiring amputation.

Conclusion: Primary topical oxygen therapy within 6 hours of injury helps the heel pad to survive and return to functional levels in traumatic avulsion. A new classification system based on the pattern of injury has also been proposed.

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Course of Treatment and Rate of Successful Salvage Following the Diagnosis of Deep Infection in Patients Treated for Pilon Fractures (AO/OTA 43)

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Purpose: Optimal treatment strategies and complication rates for surgical treatment of pilon fractures have been established. However, there is a paucity of detailed information regarding expected course and outcomes following development of a deep infection in surgically treated pilon fractures. Our primary aims are to report rate of successful salvage and describe typical treatment course relative to various injury and patient variables.

Methods: We undertook a retrospective chart review of infected pilon fractures treated over a 6-year period at a single academic trauma center. End points of treatment, defined as healed fracture with joint preservation, tibiotalar fusion, or amputations, were identified. Success rate of attempted salvage and total procedures required to reach definitive treatment end point were recorded. Statistical analysis using unpaired *t* test was performed to determine impact of both patient and injury variables on treatment course and success.

Results: We identified 409 pilon fractures in 399 patients. Deep infection was diagnosed in 62 (15%) of 409 cases. 58 fractures had >6-month follow-up and comprised our study population. Initial treatment utilized a staged protocol including external fixation and delayed open reduction and internal fixation in 49 (84%) of 58 fractures. 79% (46 of 58) were AO/OTA 43C fractures. 55% (32 of 58) were open fractures; 53% of these were Type 3 based on the Gustilo-Anderson classification system. Salvage was attempted in 56 of 58 patients and 84% (47 of 56) were successfully salvaged to union. Patients who were successfully salvaged required an average of 3.4 (±2.4) total procedures following diagnosis of infection, 2.2 (±1.7) débridements, and 1.1 (±1.3) reconstructive procedures. Average time from injury to end point of treatment was 17.7 months. Six patients went on to amputation after attempted salvage, with a mean of 6 (±3.6) total postinfection procedures, 3 (±1.7) débridements and 3 (±2) reconstructions. Two patients underwent amputation without attempted salvage. Hypertensive patients (n = 20) required an average of 3.5 more total procedures ($P = 0.03$). There was no significant correlation, positive or negative, between diabetes, smoking, open injuries, and obesity (body mass index >30.0) and number of required procedures or success of treatment.

Conclusion: Considerable morbidity follows the diagnosis of deep infection, with 14% of patients ultimately treated with amputation. Successful salvage can be reliably anticipated in over 80% of patients, but typically requires more than 3 additional procedures. Independently, diabetes, smoking, open fractures, and obesity did not decrease the success of salvage. However, hypertensive patients are at increased risk for requiring a greater number of procedures to definitively treat. This series serves as a framework for discussions regarding anticipated success of and course of treatment, helping align patient and surgeon expectations.

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Ankle Radiographs in the Early Postoperative Period: Do they Matter?

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Purpose: Orthopaedic trauma surgeons order high numbers of plain film radiographs. While the nature of the specialty necessitates this, some patients may not benefit from frequent plain radiographs. One example is the 2-week postoperative radiograph of a patient with an ankle fracture. The incidence of ankle fractures is estimated at 187 per 100,000 adult person-years. Based on data from the 2010 US Census and the American Medical Association Current Procedural Terminology (CPT) system, a reduction by one 3-view radiographic plain film ankle study during the course of care for each ankle fracture in the US can yield roughly $34.6 million in annual savings to the US health system. Interestingly, very little evidence exists on the utility of radiographs of ankle fractures in the immediate postoperative period. This study assessed if early postoperative ankle radiographs decrease perioperative complications.

Methods: A retrospective review of CPT codes at a major Level I trauma center identified 1830 patients who underwent surgical fixation of an ankle fracture between January 1, 2001 and January 1, 2010. We compared complication rates among patients who had ankle radiographs in the early postoperative period (7-21 days) versus those that obtained radiographs in a delayed fashion (22-120 days). Patients without ankle radiographs between postoperative days 7 and 120 were excluded. Complication rates were compared between the Early group (7-21 days) and the Late group (22-120 days). Each chart was reviewed for complications secondary to surgery. Any instance of infection, nonunion, or failure of fixation requiring surgical intervention of the ankle fracture was considered a complication. Lastly, χ^2 analysis was used to determine any statistical difference in complication rates between the two groups.

Results: 1411 patients met inclusion criteria. 889 were included in the Early group and 522 were included in the Late group. Overall 93 patients with complications were identified (6.59% complication rate). The Early group contained 62 patients (6.97% complication rate) with complications and the Late group had the remaining 31 patients (5.94% complication rate). A χ^2 test revealed no statistical significance in complications between the Early group and the Late group.

	No complications	Complications	Total
Early radiograph	827	62	889
Late radiograph	491	31	522
Total	1318	93	1411

P value for association between radiograph time and complication rates: 0.51

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Conclusion: These results demonstrate that no significant difference exists in complication rates following ankle fracture fixation between the Early and Late radiograph group. Some early postoperative radiographs may be important due to tenuous fixation, poor bone quality, or concern of compliance. This investigation questions the justification of routine radiographs of surgically treated ankle fractures.

Calcaneal Avulsion Fractures: A Case Series and Prognostic Factors

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Background/Purpose: Calcaneal avulsion fractures are a rare variant of calcaneal fractures. While the calcaneus is the most frequently fractured tarsal bone, avulsion fractures have been shown to make up only 1.3% to 2.7% of calcaneus fractures. The previous literature regarding calcaneal avulsion fractures is therefore limited to technique tips, case reports, and short case series due to the infrequency of this injury and little has been reported regarding prognostic factors or outcomes. Due to soft-tissue threatening and problems with fixation we hypothesize that calcaneal avulsion fractures have poor outcomes, often necessitating secondary surgeries for either revision fixation or procedures to address soft-tissue problems. We describe the results of a case series of 33 patients.

Methods: A retrospective review was undertaken at 2 Level I trauma centers of all calcaneus fractures treated at our institutions from 2002 to 2011. After radiographic review, patients with calcaneal avulsion fractures as classified by Beavis et al were identified. Tongue-type fractures, as described by Essex-Lopresti, where the posterior facet is in continuity with the fractured superior tuber, were excluded. Age, sex, mechanism of injury, initial treatment, and associated medical comorbidities were documented. The medical record was additionally surveyed for documentation of posterior soft-tissue threatening. Need for additional surgeries after the index procedure including revision fixation, irrigation and débridement, flap coverage, and/or amputation was noted as the primary outcome for review.

Results: 509 patients who sustained calcaneal fractures were reviewed. Of those, 33 patients who sustained calcaneal avulsion fractures were identified. There were 15 men and 18 women. The mean age was 53 years of age (range, 17-89 years). According to the classification system as described by Beavis et al, there were 5 type I fractures and 28 type II fractures. There were no type III fractures seen in our series. The skin was threatened in 12 (36%) of 33 fractures and 3 (9%) were open at the time of presentation. 11 of 33 (33.3%) underwent nonsurgical treatment while 22 (66.7%) underwent surgical treatment. Average fracture fragment displacement in those treated nonsurgically was 6.98 mm while those treated surgically was 17.4 mm. Of the 22 who underwent surgery, 6 (27%) had a failure of initial fixation. There was a need for secondary surgeries in 12 cases (36.4%). Of the 12, 4 underwent 1 additional procedure after the index procedure, 5 underwent 2 additional procedures, and 3 underwent 3 or more additional procedures. 2 of 10 (20%) eventually went on to below-knee amputation. The average number of additional surgeries needed was 2.25. Of those who required additional surgeries, 10 of 12 (83%) were for wound complications and 2 of 12 (17%) for failure of fixation only. 3 of 12 (25%) had both failure of fixation and wound complications necessitating additional surgery. Skin threatening and fracture displacement were shown to have a statistically significant association with need for surgery ($P = 0.032$). Peripheral vascular disease, hypothyroidism, and an increased comorbidity score were statistically associated with wound-healing complications as well as the need for secondary surgeries.

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Conclusion: Calcaneal avulsion fractures present a difficult problem with a relatively high incidence of soft-tissue problems, failure of fixation, and need for additional surgeries. Our results indicate that initial fracture displacement indicates a need for surgical reduction and fixation, but comorbid conditions portend a poor prognosis with a significant association with wound complications and need for additional surgeries.

See pages 91 - 132 for financial disclosure information.

Ankle Fractures and Employment: A Life-Changing Event for Patients

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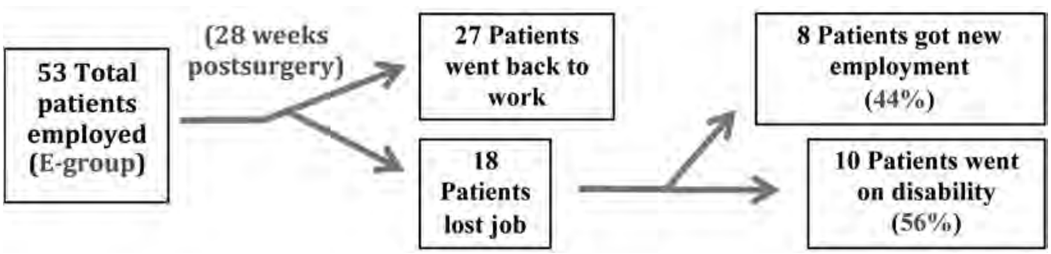
Purpose: The LEAP (Lower Extremity Assessment Project) study has clearly documented the tendency for limb-threatening lower extremity trauma to increase patients' risks for unemployment and long-term disability. Patients with a mangled extremity are often immediately counseled in this regard based upon prior studies such as LEAP. However, there is scant literature on the long-term effects of orthopaedic injuries like isolated ankle fractures on employment. This study explores the history of employment and disability status in patients who underwent open reduction and internal fixation (ORIF) of an isolated ankle fracture.

Methods: After obtaining IRB clearance, the orthopaedic trauma database was reviewed using CPT and ICD-9 code information in order to identify patients who were between the ages of 18 and 65 years and underwent ORIF of lateral malleolar, bimalleolar, and trimalleolar ankle fractures at a single Level I trauma center from 2008-2010. Each chart was then reviewed, and patients with multiple injuries were excluded leaving only isolated operative ankle injuries. A 10-minute, 20-question phone survey/interview was developed and reviewed by two orthopaedic trauma surgeons. Patients were surveyed via the phone regarding their employment status, disability status, and capability to perform tasks at work during the 2 to 5 years between their ankle surgery and the time of survey.

Results: 573 patients with ankle fractures were identified in the relevant time period. 457 met inclusion criteria and were contacted by phone. 86 patients were successfully contacted and completed the telephone interview. The average age of respondents was 48 years, with 43% (37) females and 57% (49) males. 53 (62%) patients were employed (E) at the time of the index ankle injury, and 33 (38%) were unemployed (UE). Following their injury 27 patients (51%) of the E group returned to their original work after an average absence of 28 weeks from the date of surgery, while 18 (34%) in the E group stated that they lost their job specifically due to their ankle injury. The remaining 8 (15%) patients in the E group chose to retire and not pursue new employment or disability. Of these 18 patients who lost their job following the index injury, 8 (44%) obtained new employment. 10 patients (56%) in this group that lost employment after surgery did not find new jobs and went on to receive some form of short- or long-term disability.



Conclusion: This study demonstrates the potentially serious employment implications for patients with ankle fractures and the influence these injuries can have on individuals' lives and contributions to society. Job loss, long-term unemployment, and disability are life-changing, but common, after-effects of an ankle fracture—as reported by 34% of initially employed respondents who lost their jobs after injury. Orthopaedic surgeons must effectively counsel patients on the significant influence of ankle fractures on their employment and life, as this injury is often considered relatively minor to patients and surgeons.

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The Treatment of Comminuted Talar Neck Fractures: The Effect of Lateral Plate Augmentation on Outcomes

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Purpose: Fractures and fracture-dislocations of the talar neck account for 50% of all major injuries to the talus. When talar neck comminution is present, screw fixation alone has limitations in restoring anatomic alignment and rigid fixation for these unstable injuries, which can lead to nonunion and malunion. Recently, minifragment plates have been used to maintain both length and overcome the limitation of isolated screw fixation. The purpose of this study is to evaluate a series of displaced and comminuted talar neck fractures treated with screw fixation and lateral plate augmentation. Our hypothesis was that this technique would prevent shortening, minimize neck nonunions, and decrease the rate of osteonecrosis (ON) associated with complex Hawkins II through IV fractures.

Methods: Between January 2005 and December 2010, all OTA 81.B2/B3 fractures that were treated with open reduction and internal fixation (ORIF) and lateral plate augmentation using two separate medial and lateral incisions were reviewed. 51 patients with 53 fractures were identified. There were 24 Hawkins II/81.B2 and 29 Hawkins III and IV/81.B3 injuries. Patients were followed for a minimum of 24 months. Radiographic data were collected and evaluated for union, malunion/nonunion, ON, arthritis, and complications. Clinical outcomes were also evaluated.

Results: 45 patients (46 fractures) were available for a minimum of 24 months follow-up (range, 12-72 months). Eight of these were open, highly comminuted (81.B3) fractures, including 2 extruded talus fractures. 40 fractures healed primarily while 4 required an additional bone graft in order to achieve union, resulting in a 96% (44 of 46) union rate. There was no evidence of malunion and associated hindfoot varus due to neck shortening. Radiographic evidence of ON was seen in 8 fractures (17%). ON with collapse occurred in 4 (9%). Five patients required arthrodesis procedures due to posttraumatic arthrosis including all 4 with talar collapse. Superficial wound problems were present in 4 patients (9%), all which resolved. 30 (67%) returned to their previous employment. The average visual analog scale score was 3.4 (range, 0-8). The mean AOFAS (American Orthopaedic Foot & Ankle Society) score was 82 (range, 72-92) and the mean MFS (Maryland Foot Score) was 84 (range, 71-94).

Conclusion: Treatment of comminuted fractures of the talar neck using screw fixation in combination with lateral plate augmentation through dual incisions results in lower rates of nonunion and talar collapse from ON compared to historical rates in the literature. Functional outcomes are also within an acceptable range for this injury pattern. The addition of lateral minifragment plates should therefore be given consideration whenever the surgeon is confronted with comminuted OTA 81.B2/B3 fractures of the talar neck.

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Effect of Chronic Heavy Smoking on Ankle Fracture Healing

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Background/Purpose: Cigarette smoking is associated with increased risk of osteomyelitis and delayed union/nonunion in long bone fractures. However, the effect of cigarette smoking on the outcome of ankle fracture remains unknown. In this study we analyzed the effect of chronic heavy smoking on closed ankle fracture healing and outcomes.

Methods: Over a 4-year period out of 1899 patients treated with ankle fractures in our institution, 173 (9%) met the inclusion criteria. Chronic heavy smoking was defined as daily smoking of greater than 20 cigarettes per day for over 20 years. An age- and sex-matched control group (n = 173) (nonsmokers, closed ankle fractures) were randomly selected for comparison purposes. Fractures were classified as per the Lauge-Hansen classification system. Patient demographics, preexisting comorbidities, medication, mechanism of injury, and clinical details including surgical procedures were collected. Primary outcome factors studied were time to fracture and wound healing. Secondary outcome factors studied were postoperative complications (pain, bleeding, swelling, infection, compartment syndrome, neurovascular impairment, and scarring) and incidence of delayed union, non-union, and surgical reintervention. Radiological fracture healing was defined as radiologically evident bridging trabeculae of the defect and increased density at the fracture site. Both cohorts were followed up for a minimum period of 18 months.

Results: The mean age of the heavy smoker group (121 males, 52 females) was 43 years. In the control group (118 males, 55 females), the mean age was 47 years. Other associated injuries between the groups included knee and metatarsal injuries. Both cohorts were matched to the type of fractures. For the chronic heavy smokers group, 85 patients required open reduction and internal fixation (ORIF). The rest were treated conservatively with cast immobilization for 6 weeks. For the control group, 78 patients required ORIF and the rest were treated conservatively. Patients requiring surgical fixation between both groups were similar in terms of co-morbidities, fracture type and surgical requirements. None of the patients in both cohorts suffered from diabetes mellitus. There was no significant difference between both groups in terms of fracture healing for those fractures managed nonsurgically ($P = 0.43$). A statistically significant delay in fracture healing was noted between the smoking (mean, 16 weeks; range, 12-19) and the control (mean, 9 weeks; range, 8-10) groups ($P < 0.001$). Further analysis of the surgical cohort revealed a significant correlation between smoking and postoperative duration of pain ($P = 0.005$) and fracture site tenderness ($P = 0.004$). Smokers are also at significantly higher risk of developing superficial wound infection ($P = 0.048$), delayed union of over 6 months duration ($P = 0.012$), and overall healing time required ($P = 0.002$).

Conclusion: Chronic heavy smokers with ankle fractures requiring surgical intervention should be informed of their increased risk of delayed fracture and wound healing. Orthopaedic surgeons need to encourage their patients to enter into smoking cessation programs.

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Temporary External Fixation for Provisional Reduction of Displaced OTA 82-C Calcaneus Fractures

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Purpose: Calcaneus fractures usually occur from high-energy trauma and are associated with local soft-tissue injury that complicates early definitive open reduction and internal fixation, with wound healing problems reported to be as high as 43%. Therefore, most authors allow for a period of soft tissue rest prior to proceeding with definitive surgical intervention. To aid delayed definitive anatomic reduction and to improve hindfoot height and aligment in poor surgical candidates, we implemented the use of a medially based, three-pin external fixator construct that is applied from the tibia to the tuber to the 1st metatarsal. The purpose of this study is to evaluate whether this staged approach can improve and maintain fracture alignment during a preoperative waiting period.

Methods: Patients with AO/OTA type 82-C calcaneus fractures treated acutely with application of a medially based, three-pin, joint-spanning external fixator, followed by closed reduction, were reviewed. Radiographic measurements were independently performed by the senior author and two trauma-fellowship-trained orthopaedic surgeons. Böhler's angle and tuber-varus angle measurements were performed on lateral and axial radiographs at injury, after external-fixation, at final follow-up in the external fixator, and after definitive fixation. Interrater results of the reader's radiographic measurements were obtained by Pearson's correlation coefficient.

Results: A consecutive cohort of 27 patients with 29 fractures treated with a medially-based, three-pin external fixator construct between September 2004 and May 2012 were reviewed. Mean time from injury to application of external fixator was 4.5 days (standard deviation [SD] ±6.2). Compared to injury radiographs, there was a mean correction of 14.4° in Böhler's angle and 6.5° correction in tuber-varus angle ($P < 0.05$). The mean duration of external fixator use was 6.6 weeks (SD ±6.2), as several patients had definitive closed treatment with an external fixator. There was no significant loss of Böhler's angle ($P = 0.73$) or tuber-varus angle ($P = 0.11$) during the course of external fixation. The interobserver reliability for Böhler's angle and tuber varus-angle was 0.85 and 0.70 respectively. Seven of the 29 fractures exhibited signs of infection or wound dehiscence; however, 4 of these occurred in patients who had an open medial injury, and treatment was initiated prior to external fixation. Only 2 complications were directly related to external fixation; a deep pin tract infection requiring formal irrigation and débridement and a superficial pin tract infection that was successfully managed with oral antibiotics. The final complication, a deep infection, occurred after definitive ORIF and was also managed with irrigation and débridement and antibiotics to resolution.

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Conclusion: A medially based, three-pin external fixator can be used to significantly improve and maintain calcaneal height and tuber alignment in displaced calcaneus fractures. The implications of this technique include: (1) the potential to reduce soft-tissue complications by preventing tissue contraction, (2) make an anatomic reduction easier to accomplish at the time of definitive managment, and (3) render an improved result through better hindfoot alignment in a poor surgical candidate.

See pages 91 - 132 for financial disclosure information.

Thyroxin Level Control in Hypothyroid Patients and Ankle Fracture Healing

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Background/Purpose: Thyroid hormones affect bone remodeling in patients with thyroid disease by acting directly or indirectly on bone cells. In this retrospective comparative analysis, we looked at the perioperative thyroxin levels in patients with hypothyroidism sustaining ankle injuries and its effect on fracture healing.

Methods: A total of 65 patients met the inclusion criteria (known hypothyroidism controlled with thyroxin supplements, closed ankle fractures requiring surgical fixation). Baseline serum thyroxin was documented at 4 different intervals: preoperative, immediate postoperative, late postoperative, and first outpatient clinic follow-up (within 4 weeks of surgery). An age- and sex-matched control group was identified that does not suffer from thyroid or any other hormonal disorder. Both groups were also matched to their Lauge Hansen fracture classifications and surgical fixation requirements. Primary outcome factors studied were thyroxin level control (T4), time to fracture, and wound healing. Secondary outcome factors analyzed included duration of postoperative pain, bleeding, swelling, infection, delayed fracture union and nonunion, neurovascular impairment, scarring, and compartment syndrome. All patients were followed up for a minimum of 18 months.

Results: Patients with poor thyroxin level control (n = 23) compared to good thyroxin control (n = 42) in the first 4 weeks postoperatively required longer mean time to achieve fracture union (14 weeks compared to 9 weeks) (P <0.001). Compared to controls (mean time to union 8 weeks), patients with poor thyroxin control required longer time to fracture healing (P = 0.003,) but this was not the case if patients had good thyroxin control (P = 0.043). However, this was not the case for wound healing (P = 0.056). Assessment of secondary outcome factors revealed a significant correlation between poor thyroxin level control in hypothyroid patients and incidence of swelling (P = 0.024), delayed union (P = 0.003), and overall increase in healing time (P <0.001).

Conclusion: Hypothyroid patients with poor thyroxin level control sustaining ankle fractures are more likely to suffer from fracture healing problems including delayed union.

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Resistance to Forced Dorsiflexion of 6 Plaster Short Leg Splint Designs

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Purpose: The common practice for emergent management of many lower extremity injuries is to temporize or treat the injury with a plaster splint. Currently there are very limited mechanical data in the literature describing the strength and stiffness of plaster splint designs. The purpose of this study is to measure the stiffness and yield strength of 6 commonly used short leg ankle splints.

Methods: Eight articulating prosthetic legs were fabricated in our laboratory and used to test 6 ankle splint designs (Figure 1): (1) sugar tong over posterior splint, (2) posterior splint over sugar tong, (3) sugar tong with plantar plate, (4) sugar tong only, (5) posterior splint only, and (6) posterior splint with diagonal struts. Models were wrapped in 3 layers of cast padding, followed by the plaster splint that was held with 6-in Ace bandages with the ankle at 90°. Plaster slabs were composed of 10 layers of 4-in plaster (Specialist, BSN Medical) and allowed to cure 24 hours before testing.

Specimens were tested on a servohydraulic testing machine with a load applied to the metatarsophalangeal joints to dorsiflex the ankle at a rate of 8.5 mm/sec. Data were analyzed using repeated-measures analysis of variance with Tukey post hoc testing as appropriate. Our hypothesis was that there would not be a significant difference between any of the treatments.

Results: The results of our study are presented in Figure 2. Splints with a single slab design were significantly weaker and less stiff than splints composed of more than one slab. Sugar tong splints with a posterior component were significantly stronger and stiffer than those with a plantar plate. Posterior splints with side struts were stronger and stiffer than all other designs.

Conclusion: This study has shown the beneficial effects of multiple plaster components on the strength and stiffness of plaster short leg splints. The results have also shown the benefits of placing the layers in an order where the interfaces are in compression.

Figure 1: Six short leg splint designs.

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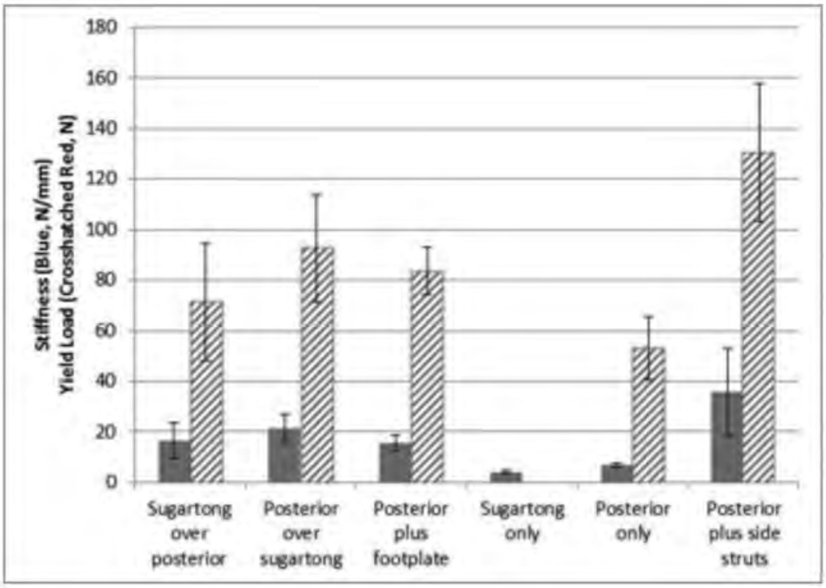

Figure 2: Yield strength and stiffness of 6 short leg splint designs.

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Outcomes of Transsyndesmotic Ankle Fracture Dislocations—The "Log Splitter"

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Purpose: The purpose of this study was to describe and investigate the injury pattern in which the talus is axially impacted into the syndesmosis, leading to a transsyndesmotic fracture dislocation, or "log-splitter" injury. Compared to most ankle fractures, this injury pattern is believed to result from higher energy mechanisms and potentially result in worse outcomes.

Methods: Over a 2-year period, 512 ankle fractures were surgically treated at a single Level I trauma center. Of these, 28 presented as transsyndesmotic fracture dislocations. All patients were prospectively collected and followed until union or until need for revision surgery. Along with radiographic outcomes, American Orthopaedic Foot & Ankle Society (AOFAS) and Short Musculoskeletal Function Assessment (SMFA) questionnaires were completed on each patient.

Results: The mean age was 44.1 ± 15.2 years (range, 19-70 years) with 64.3% males. Fracture characteristics included 50% open fractures, 25% with an extruded talus, and an average syndesmotic widening of 31.0 ± 11.0 mm. Anterior, neutral, and posterior dislocations occurred in 17.9%, 42.9%, and 39.2% of patients, respectively. A fracture of the tibial articular surface occurred in 78.6% of injuries, with a Tillaux fragment occurring in 17.9% and articular impaction in 21.4% of injuries. A fibula fracture occurred in all but one patient. Mean follow-up was 8.7 ± 3.6 months. Dorsiflexion and plantarflexion at final follow-up was 9.8 ± 6.4° and 33.5 ± 13.4°, respectively. Complications included a 10.7% infection and 24.3% nonunion rate. Average AOFAS score was 69.2 ± 27.6, while SMFA Dysfunction index was 32.9 ± 28.6 and SMFA Bother Index 34.5 ± 29.5.

Conclusion: While commonly reported and treated as traditional ankle fractures, transsyndesmotic fracture dislocations, or "log-splitter" injuries, appear to have outcomes similar to high-energy pilon fractures. Although articular impaction of the tibia was seen in only 21% of the injuries, both the AOFAS and SMFA scores closely resemble that of pilon fractures. This information can be useful for prognostic purposes and when counseling patients and families.

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Hemiarthroplasty Versus Osteosynthesis for Undisplaced and Stable Femoral Neck Fractures

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Purpose: The incidence of hip fractures in the United States and Europe is high and continues to increase. The best treatment for femoral neck fractures is still under debate. The purpose of the study was to compare the complication, reoperation, and mortality rates of hemiarthroplasty and osteosynthesis in patients with impacted / stable osteoporotic femoral neck fractures.

Methods: We retrospectively compared the complication, reoperation, and mortality rates between two groups that were matched in age, gender, BMI (body mass index) and ASA (American Society of Anesthesiologists) scores. All included patients sustained Garden I or II femur neck fractures. Either hemiarthroplasty or osteosynthesis was performed based on surgeon preference. Osteosynthesis was performed with 3 parallel cannulated screws. The minimum follow-up was 24 months. All patients were over 60 years old. The primary outcomes were complications of surgery and the need for revision surgery. A secondary outcome of the study was the cost of the primary surgery.

Results: The mean age of the 98 patients in the osteosynthesis group was 82 years (range, 60-104) and 80 years (range, 60-90) in the 38 patients treated with hemiarthroplasty. Mean follow-up was 44 ± 1.4 months (range, 24-92 months). Overall complication, reoperation, and 1-year mortality rates were similar in both groups. Infection was significantly higher in the hemiarthroplasty group. In a logistic regression model analysis, the complication, reoperation, and 1-year mortality rates were similar between patients over and under 80 years old, in both the hemiarthroplasty and osteosynthesis groups. Intraoperative blood loss and length of stay were significantly lower in the osteosynthesis group. The hemiarthroplasty group had a much higher cost of surgery.

Conclusion: Hemiarthroplasty has no benefit in decreasing complications and reoperations for stable femoral neck fractures in the elderly. The costs of surgery and infection rates are higher with hemiarthroplasty as compared to osteosynthesis for these stable fracture patterns.

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Comparison of Lateral Locked Plating With Additional Distal Fixation and Antiglide Plating for Fixation of Distal Fibular Fractures in Osteoporotic Bone

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Purpose: Antiglide plating has been described as the biomechanically strongest construct for fixation of distal fibula fractures in osteoporotic bone. The purpose of this study is to compare lateral periarticular distal fibula locked plating to antiglide plating in the setting of an osteoporotic, unstable distal fibula fracture.

Methods: AO/OTA 44-B2 distal fibula fractures were created in 16 paired cadaveric ankles. The bone mineral density (BMD) was determined. The fractures were fixed with a lateral locking plate and an independent lag screw or an antiglide plate with a lag screw through the plate. With the ankle loaded in the axial plane and unconstrained in the coronal and sagittal planes, the specimens underwent stiffness, cyclic loading, and load-to-failure testing. The energy absorbed until failure, torque to failure, construct stiffness, angle at failure, and energy at failure were recorded.

Results: The BMD was not significantly different between the two treatment groups (P = 0.50). Two of the lateral locking plate constructs and four of the antiglide plate constructs failed during cyclical loading. The energy absorbed to failure of the lateral locking construct (29,515 ± 11,958 Nm-deg) was greater than the antiglide construct (24,968 ± 13,190 Nm-deg) (P = 0.03). The lateral locking construct had a higher torque to failure (P = 0.02) and construct stiffness (P = 0.04). The angle at failure trended to be greater for the lateral locking construct (P = 0.07).

Conclusion: The distal fibula periarticular locking plate is biomechanically stronger than a nonlocking one-third tubular plate applied in antiglide fashion for the treatment of AO/OTA 44-B2 osteoporotic distal fibula fractures.

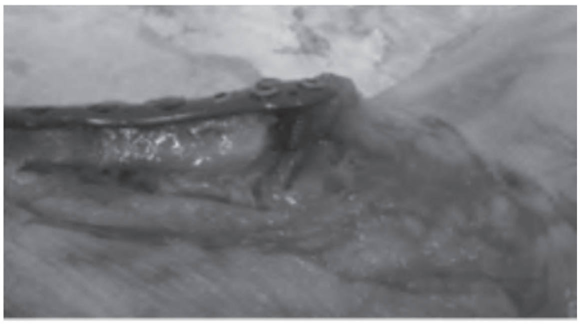

Figure 1: Locking plate failure through catastrophic distal cutout.

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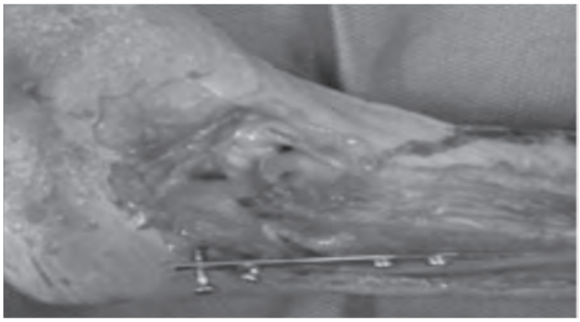
Figure 2: Antiglide plate failure through sequential screw loosening.



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A Simple Way to Improve Hospital Medical Care for Hip Fracture Patients: Testing Protein Levels

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Background/Purpose: Hip fractures cause significant morbidity and mortality in older people. The orthopaedic POSSUM (physiological and operative severity score for the enumeration of mortality and morbidity) score (OPS) is widely accepted for the evaluation of mortality and morbidity risks in orthopaedic patients, but it does not take malnutrition parameters into account. Low preoperative albumin and protein levels, a marker for malnutrition, could be of major importance in the management of these patients. There are no guidelines in Israel for testing protein levels in patients presenting with hip fractures, nor are these tests routinely performed. The purpose of this study was to compare the impact of protein levels with that of the physiological OPS and its components on the mortality and morbidity risks of patients with hip fractures.

Methods: Files of 2269 consecutive patients undergoing surgery for hip fracture in our medical center between 2008 and 2011 were retrospectively evaluated. OPS parameters were available for 1770 patients. Albumin and total protein levels had been tested in only 387 (17.1%) and 279 (12.3%) patients, respectively. The relative impact of protein levels and the components of the physiological OPS were compared by multivariate logistic regression models for mortality and composite outcome (perihospitalization or perioperative mortality, additional surgery during hospitalization, 7-day hospital readmission, transfer to intensive care, perihospitalization deep vein thrombosis, myocardial infarction, and pulmonary or systemic embolism). The Charlson comorbidity score, provision of intraoperative transfusion, and time from hospital arrival to surgery were also assessed. The area under the curve (AUC) compared the predictive value of the OPS to that of models with and without protein level data for mortality.

Results: Preoperative albumin and total protein levels were inversely associated with mortality in multivariate models (albumin g/L OR [odds ratio] = 0.89, $P = 0.009$; protein g/L OR = 0.92, $P = 0.009$) and in composite outcome (protein OR = 0.94, $P = 0.014$). The AUC for the prediction of mortality by the OPS (n = 1770) was 0.632 (95% CI [confidence interval]: 0.580-0.684, $P < 0.001$), while the AUC for a model including protein levels (n = 279) performed better (AUC = 0.742 [$P < 0.001$, 95% CI: 0.649-0.834]).

Conclusion: Lower preoperative protein and albumin levels are strongly associated with an increased risk for mortality and poor outcomes in patients operated for hip fracture. Protein and albumin levels should be included in the routine laboratory tests for patients presenting with hip fractures. Protein supplementation should be provided when indicated.

POSTER ABSTRACTS

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Immediate Weight Bearing as Tolerated After Locked Plating of Fragility Fractures of the Femur

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Purpose: This study was undertaken to evaluate whether locked periarticular femoral plates could withstand immediate weight bearing as tolerated following open reduction and internal fixation.

Methods: A total of 31 patients underwent locked femoral plating using the Smith & Nephew Peri-Loc system between 2007 and 2011. All surgery was performed by a single surgeon. Patients included were those who were physiologically aged and sustained a ground level fall resulting in a femur fracture. Patients were either kept non–weight bearing (NWB) for a minimum of 6 weeks or allowed immediate weight bearing as tolerated (WBAT). Charts and radiographs were retrospectively reviewed. Two patients were lost to follow-up in the NWB group and two patients were lost to follow-up in the WBAT group, leaving a total of 27 patients for review. Mortality rate was reviewed at 6, 12, and 13 months. Radiographs were reviewed for fracture healing and hardware failure.

Results: We had 13 patients in the NWB group and 14 patients in the WBAT group. There was no significant difference between the two groups for age, smoking, diabetes, or use of bisphosphonates. Two screws broke in one NWB patient at 9 months, and one screw broke in one WBAT patient at 10 months. This was not statistically significant. No patients had failure of fixation requiring reoperation. At 6 months, the mortality rate in the NWB group was 23% versus 0% in the WBAT group ($P = 0.06$, relative risk [RR] = 7.35; 95% confidence interval [CI] 0.45-207.9). At 13 months, the mortality rate in the NWB group was 39% versus 7% in the WBAT group ($P = 0.05$, RR = 5.39; 95% CI 0.72-40.20).

Conclusions: Our results suggest that patients with low energy femur fractures may safely weight-bear as tolerated following fixation with the Smith & Nephew Peri-Loc system. There is a trend toward decreased mortality at 6 months following fracture fixation for patients allowed immediate weight bearing as tolerated, and a statistically significant difference in mortality at 13 months following fracture fixation for patients allowed immediate weight bearing as tolerated. Weaknesses of our study include retrospective design and small numbers. We cannot extrapolate our hardware failure data to other brands of locked plating systems. Because early mobilization appears to decrease the mortality rate in this elderly population, our study warrants further investigation into immediate weight bearing as tolerated following locked fixation of femur fractures.

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Atypical Femur Fractures in Patients on Chronic Bisphosphonates: Does Geometry Matter?

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Purpose: In 2004-2005, cases of "atypical" femur fractures began to be reported and linked to patients who had been on bisphosphonates for a prolonged period of time. This study is designed to evaluate the proximal femoral geometry in patients with primary osteoporosis on chronic bisphosphonate therapy. We hypothesize patients with atypical femur fractures will have more varus geometry than the controls.

Methods: The femoral neck-shaft angle (NSA), femoral neck length (FNL), and the tip of the greater trochanter to the center of the femoral head (THC) distances were measured on 35 patients with atypical femoral shaft fractures and 35 patients with primary osteoporosis on chronic bisphosphonate therapy (mean exposure 8.4 years vs. 5.4). Patients with characteristic lateral cortical thickening, stress lines, and thigh pain were included in the fractured group. Both hips were measured when available (134 total hips). All measurements were made from plain radiographs using Orthoview software.

Results: There is a statistically significant difference in the NSA of patients with atypical femur fractures and those on bisphosphonates without fracture (mean 129.11° vs 133.57°; P <0.001). While there is a large overlap among the data, 39.4% of patients in the fracture group have an NSA lower than the lowest recorded unfractured patient (Figure 1). There was not a significant difference between the FNL (68 vs 82; P <0.147) or the THC (7.48 vs 6.4; P <0.138). When the patients with completed fractures were compared to those with "incomplete" fractures (lateral cortical thickening or a stress line), there was not a significant difference between the NSAs (129.6° vs 127.78°; P <0.175).

Conclusion: There appears to be an association between varus proximal femoral geometry and the propensity for patients on chronic bisphosphonates to develop atypical femoral shaft fractures. We feel our findings add a useful clinical marker that can both help identify an "at risk" subset of this population and contribute to the growing body of knowledge attempting to quantify cause of this new entity.

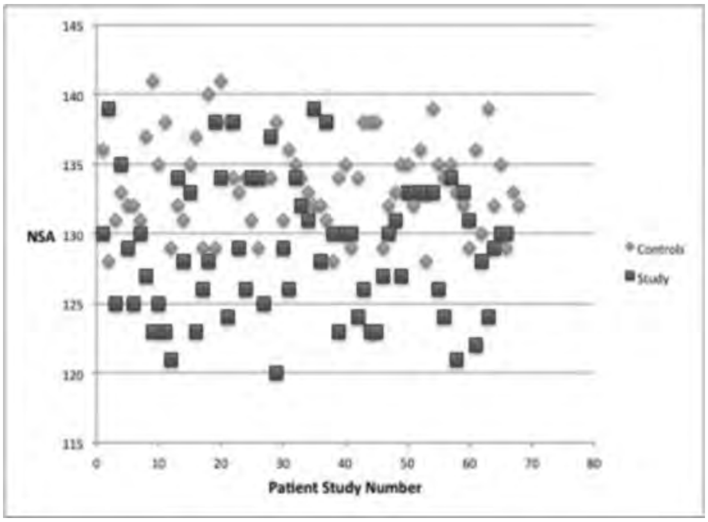

Figure 1: Distribution of NSA by group.

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Locked Plating Versus Nonoperative Management of Displaced Proximal Humerus Fractures in the Elderly

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Purpose: The purpose of this study was to compare the outcomes of locked plate fixation and nonoperative care in the treatment of displaced proximal humerus fractures in individuals aged 60 years or older. Our hypothesis was that patients treated nonoperatively would have outcomes that were similar to those treated operatively.

Methods: From our prospectively collected trauma database, we identified 207 displaced proximal humerus fractures that met all inclusion and exclusion criteria. For each patient, the medical record and available radiographs were retrospectively reviewed to obtain data on baseline characteristics, method of treatment, radiographic outcome, and complications sustained. For patients who accepted our invitation to return for evaluation, clinical outcome was assessed using the Constant questionnaire, the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, the Short Musculoskeletal Functional Assessment (SMFA) questionnaire, and the Patient Reported Outcomes Measurement Information System (PROMIS) Physical Function Computer Adaptive Test.

Results: 207 patients met inclusion and exclusion criteria, including 146 patients managed nonoperatively and 61 patients treated operatively with locked plate internal fixation. Patients treated operatively had lower rates of malunion (40.0% vs 86.9%) but higher rates of complications including screw perforation (35.6% vs 0.0%), loss of fixation (17.5% vs 0.0%), infection (6.6% vs 0.0%), and secondary surgical procedures (13.1% vs 1.4%). 47 patients accepted our invitation to return for clinical evaluation at a mean follow-up of 3.3 years, including 22 patients treated nonoperatively and 25 patients treated with locked plate fixation. While patients in the nonoperative group tended to be older and have a greater number of comorbidities, clinical outcomes were similar in the two groups for all outcome measures including SMFA, DASH, Constant, and PROMIS.

Conclusion: In this study of displaced proximal humerus fractures in the elderly, those patients treated operatively demonstrated a lower rate of malunion but a higher rate of complications and secondary surgical procedures as compared to the nonoperative group. While patients in the nonoperative group tended to be older and have a greater number of comorbidities, clinical outcomes were similar in the two groups. Further research is required to determine the circumstances under which locked plating improves outcomes in the treatment of displaced proximal humerus fractures in the elderly.

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Geriatric Fractures About the Hip: Divergent Patterns in the Proximal Femur and Acetabulum

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Background/Purpose: Geriatric acetabular fractures are poorly understood injuries with considerable overlap between multiple orthopaedic subspecialties. They are a rapidly growing clinical problem with limited evidence-based management guidelines. These injuries often behave differently than higher-energy acetabular fractures seen in younger patients. Furthermore, unlike traditional geriatric hip fractures, which are managed by both generalists and specialists, geriatric acetabular fractures, when managed operatively, are most commonly treated by joint replacement and / or trauma specialists. The purpose of this study is to describe the epidemiologic trends, hospital course and financial aspects of geriatric acetabular fractures as compared to traditional fragility fractures about the hip.

Methods: From 1993 to 2010, the Nationwide Inpatient Sample (NIS) recorded over 600 million Medicare paid US hospital discharges. This retrospective study uses the NIS to compare Medicare patients with acetabular fractures (n = 87,771), pelvic fractures (n = 522,831), and subtrochanteric fractures (n = 170,872) to patients with traditional fractures about the hip (intertrochanteric and femoral neck, n = 3,495,742) with regard to annual trends in incidence, length of hospital stay, in-hospital mortality, transfers from acute care institutions, and hospital charges over an 18-year period.

Results: From 1993 to 2010, traditional hip fractures peaked in 1996 and declined by 25.7% by 2010. During the same 18-year period geriatric acetabular fractures increased by 67% (Spearman correlation value –0.835, *P* value <0.001). Hospital length of stay decreased by roughly 50% for all fractures types about the hip, including acetabular fractures. Hospital charges, after controlling for inflation, increased roughly 50% for all fracture types. Transfers from outside acute care hospitals declined closely for pelvic and subtrochanteric fractures when compared to traditional hip fractures (Pearson correlation 0.858, *P* value <0.001 and Pearson correlation 0.909, *P* value <0.001, respectively). Conversely, transfer from outside facilities continued to be elevated for acetabular fractures as compared to traditional hip fractures, which declined (Pearson correlation 0.357, *P* value = 0.21). In-house mortality declined with significant or near-significant correlations between acetabular, subtrochanteric, and pelvic fractures to traditional hip fractures.

Conclusion: Geriatric acetabular fractures are rapidly increasing in annual incidence while traditional hip fractures continue to decline. Reasons for these divergent patterns in fractures about the hip are unclear at this time. Furthermore, patients with these injuries are more likely to be transferred from their hospital of origin to another acute care institution, increasing costs and complications. This is likely related to their complexity and lack of consensus regarding optimal management. Given their rapidly rising annual incidence, geriatric acetabular fractures deserve closer attention and higher-quality evidence-based guidelines for treatment.

See pages 91 - 132 for financial disclosure information.

The Inclusion of Patients With Cognitive Impairment in Hip Fracture Trials: A Missed Opportunity--Systematic Review

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Background/Purpose: Over 320,000 hip fractures occur annually in North America and the incidence continues to rise with the graying of the "baby boomer" cohort. Because hip fracture is predominantly a condition of the elderly, comanifestation with cognitive impairment or dementia—a condition prevalent among the elderly as well—is not uncommon. By some estimates, 30% of the hip fracture population suffers from cognitive impairment or dementia. Furthermore, there is evidence to suggest that these patients may have poorer outcomes than those without such impairment. We performed a systematic review to determine the extent to which patients with cognitive impairment and/or dementia were included in randomized controlled trials (RCTs) assessing operative hip fracture management.

Methods: Two investigators conducted a search of three electronic journal databases (MEDLINE, Embase, PubMed) using comprehensive search terminology. All titles and abstracts were reviewed in duplicate, assessing eligibility based on the following criteria: (1) RCT study design; (2) trial assessed an operative intervention for femoral head, femoral neck, or intertrochanteric fractures; (3) publication of the manuscript in the English language; (4) original publication; and (5) published between January 2000 and June 2010. All articles that met the aforementioned inclusion criteria, and those with equivocal eligibility, were retrieved for full text review. We systematically collected descriptive data on trial characteristics, inclusion of patients with cognitive impairment, and use of cognitive assessment tools. We reported descriptive statistics and used the χ^2 statistical test for comparison between groups as appropriate.

Results: We screened a total of 1201 abstracts, and 92 were collected for full text review. 12 were excluded because they did not meet our inclusion criteria, and 8 articles could not be accessed, leaving 72 studies for inclusion. The large majority of studies were European (n = 57, 79%), single-center trials (n = 47, 65%), and compared two methods of internal fixation (n = 38, 53%). Femoral neck and intertrochanteric fractures were equally represented. 33 studies (46%) did not report the inclusion or exclusion of patients with cognitive impairment in their trials. 19 studies (26%) explicitly included patients with cognitive impairment and 20 (28%) explicitly excluded this cohort. Only two trials reported outcomes specific to cognitively impaired patients: the first was a study specific to this population; the second performed a subgroup analysis. 14 trials (19%) reported the use of a validated cognitive assessment tool. None of the RCTs that reported inclusion of cognitively impaired patients were from North American centers. There were no significant differences between RCTs that included and excluded these patients in terms of patient age, number of centers, or operative procedures compared.

Conclusion: One in three patients with hip fracture have concomitant cognitive impairment, yet eight of ten hip fracture trials exclude or ignore this population in their conduct. The ambiguity and/or exclusion of these patients misses an opportunity to study outcomes and identify factors associated with improved prognosis.

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Does Age Affect Healing Time and Functional Outcomes After Fracture Nonunion Surgery?

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Background/Purpose: Due to the concomitant setting of medical comorbidities, poor vascularization, osteopenic bone, and diminished osteogenic potential, age is a documented risk factor for fracture nonunion. The multiplicity of risk factors predicting fracture nonunion compound the success of nonunion revision surgery in the elderly. Our objective was to investigate the effect of patient age on clinical and functional outcome following long bone nonunion surgical repair.

Methods: 288 patients with fracture nonunion were prospectively enrolled in a trauma research registry between 2004 and 2012. Patients were treated irrespective of age by surgeons experienced in the care of these injuries. Length of hospital stay (LOS) at the time of surgery and past medical comorbidities were documented. Patients were tracked for a year with follow-up at regular intervals. Elderly patients >65 years of age (n = 45) were compared with nonelderly for postoperative wound complications, Short Musculoskeletal Function Assessment scores, healing, and surgical revision. Regression modeling was performed to look for associations between continuous age, smoking status, and history of previous nonunion surgery with healing.

Results: Follow-up data were available on 278 patients ranging from 18 to 91 years (mean [± standard deviation] = 48.0 [±16.8]). There were demographic differences in the aged population including significantly more females (P <0.01), medical comorbidities (P <0.01), and particularly osteopenia (P <0.05). Significantly fewer elderly reported smoking (P <0.01). Number of previous nonunion surgeries and body mass index did not differ. Rates of postoperative wound complications were similar. Surgical revision, progression to union, and union time were also similar. Elderly reported similar levels of function up to 12 months after surgery. Regression model analyses failed to show any association between age and final union nor time to union. However, the regression model did show a strong association between smoking status and previous nonunion surgeries with healing time.

Conclusion: Patient modifiable risk factors, such as smoking, and failure of previous surgical intervention were more associated with nonunion revision success than age in this trauma cohort. Advancing age may not be as strongly associated with nonunion surgery outcome in comparison with the risk factor milieu predisposing to baseline fracture nonunion.

See pages 91 - 132 for financial disclosure information.

Bone Stock Distribution Along Transsacral Corridors in the Elderly and Its Relevance to Sacral Insufficiency Fractures

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Purpose: With the demographic changes the prevalence of osteoporosis is increasing and as a consequence, sacral insufficiency fractures (SIFs) are becoming more common. There exist various treatment options; however, there is no established treatment concept and a lack of anatomical data to be used to optimize implant fixation. We detail the distribution of the bone stock along the transsacral corridors.

Methods: We studied intact pelvic CT scans of 64 adults (29 females and 35 males, mean age 74.3 years, standard deviation ±13). After semi-automated image segmentation a mean shape was created using techniques for 3-dimensional statistical modeling. Then all CT grey value data given in Hounsfield Units (HU) were elastically matched into the mean shape. There resulted an averaged bone stock distribution model of the sacrum. The bone stock in HU along the transsacral corridors S1 and S2 were analyzed.

Results: We observed a distinct bone stock distribution along the transsacral corridors (Figure 1). The first peak corresponded to cortical bone of the auricular surface. It was followed by a rapid decrease and a zone of minimal values, corresponding to the paraforaminal lateral zone also called "alar void". Intermediate values were observed in the vertebral body. This pattern was seen in both, S1 and S2, with generally lower values in S2. Females showed an overall diminished bone stock with mainly negative HU in the paraforaminal lateral zone. The largest difference in HU values between females and males was found in the vertebral bodies.

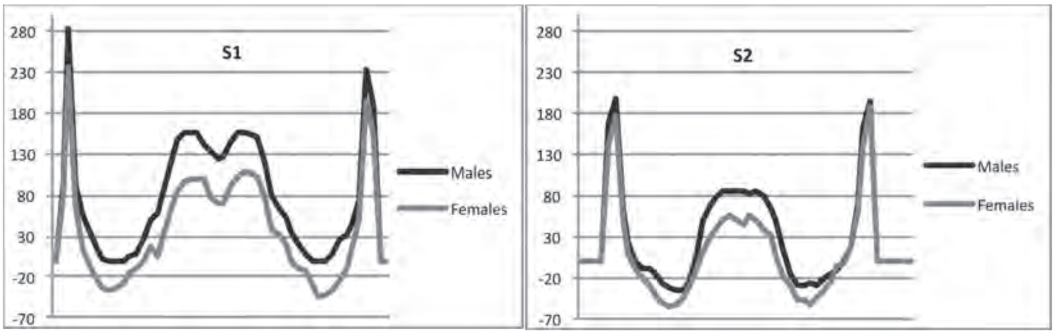

Figure 1: Mean values in HU (y axis) along transsacral corridors S1 (left) and S2 (right) demonstrating a distinct pattern of bone stock distribution in males (dark grey) and females (lighter grey).

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Conclusion: There was a variable, distinct bone stock distribution along transsacral corridors. The paraforaminal lateral zone was identified to be the weakest spot. This may explain the typical patterns and location of SIFs corresponding to Denis zone I. These anatomical findings influence screw anchorage/fixation and may lead to a better understanding of SIFs.

See pages 91 - 132 for financial disclosure information.

Preoperative Cognitive Impairment, Pain, and Psychological Stress in Hospitalized Elderly Hip Fracture Patients

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Purpose: The purpose of this study was to evaluate the prevalence of cognitive impairment (CI) in hospitalized elderly patients awaiting surgery for hip fracture. The secondary objectives were to compare preoperative ratings of pain and psychological distress among those with and without cognitive impairment, in addition to hospital length of stay (LOS). We hypothesized that diagnoses of dementia or CI would be documented infrequently in the medical record, and that compared to cognitively intact patients, patients with CI would have greater pain and psychological stress preceding operative intervention, as well as increased LOS following hip fracture.

Methods: This prospective cohort study included English-speaking individuals 65 years of age or older who were admitted to a single institution following acute hip fracture. Exclusion criteria included pathologic hip fractures, alcohol dependence, CI secondary to cerebral vascular accident, unstable psychiatric disorders, and delirium. The preoperative assessment included the Confusion Assessment Method (CAM), Montreal Cognitive Assessment (MoCA), Visual Analogue Scales (VAS) for Anxiety and Fear, Wong-Baker FACES Pain Scale, and the Everyday Cognitive Screen (EDC). Patients with and without CI were compared based on their scores on each assessment test.

Results: Of the 122 eligible hip fracture patients, 53% (N = 65) were enrolled, including 46 females (71%) and 19 males (29%). The mean age was 82.5 (standard deviation [SD] 7.4) years (range, 66-97). Of the 65 hip fracture patients enrolled in the study, 62 had evaluable baseline cognitive data. Of these, 37.1% (23) had normal cognition ($MoCA_{Total\ Score}$ ≥23), while 62.9% (39) were identified as cognitively impaired ($MoCA_{Total\ Score}$<23). Only 7.7% of patients (5 of 65) had a documented diagnosis of CI or dementia at the time of hospitalization. Preoperatively, the mean pain score for patients with CI was 5.3 (SD 2.8) compared to 2.8 (SD 1.5) in patients without CI (P = 0.0002). Prior to assessment, 30.4% of patients without CI and 17.9% of patients with CI had received analgesic medication (P = 0.28). The mean VAS anxiety (56.2 [SD 35.5]) and VAS fear scores (42.0 [SD 37.7]) for patients with CI were not statistically significantly different from those without CI (mean VAS anxiety, 50.0 [SD 38.3]; mean VAS fear, 40.0 [SD 31.7]; P = 0.524)). The mean hospital LOS was 1.1 days longer in patients with CI compared to cognitively intact patients (5.6 vs 6.7 days; P = 0.390).

Conclusion: This prospective study revealed that 62.9% of elderly hip fracture patients had CI prior to surgery, although dementia/CI was underreported in the medical record and only documented in 7.7% of patients. Patients with CI expressed statistically significantly greater degrees of preoperative pain, and a trend towards higher anxiety and fear ratings

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compared to those without CI. In this small cohort, higher pain levels in cognitively impaired patients may have been due to undermedication. High levels of pain, fear, and anxiety can influence long-term outcome following hip fracture, thus appropriate identification of preoperative CI and appropriate pain control is critical in order to optimize patient outcomes. Larger prospectively controlled trials are needed to determine optimal methods for identifying and caring for cognitively impaired hip fracture patients.

See pages 91 - 132 for financial disclosure information.

The Disutility of Preoperative Diagnostic Testing for Geriatric Hip Fractures

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Background/Purpose: Geriatric patients who undergo delayed surgery after presenting to the hospital with a low-energy hip fracture have an increased risk of mortality compared to patients who undergo earlier surgery. However, because of confounding, the assertion that delays to surgery cause increased mortality remains controversial. To an extent, common practice has come to accept that delays imposed to improve the patients' ability to tolerate the perioperative environment are admirable; however, delays resulting in limited optimization of the patient may be detrimental. Therefore, we ask, "Is preoperative testing associated with an increased interval between presentation and surgery itself?" Similarly, we ask, "Among those patients subjected to testing, how often were preoperative interventions performed as a result of the testing?"

Methods: Electronic medical records were reviewed (IRB approved) for 100 consecutive geriatric hip fractures admitted through the Emergency Department (ED) who underwent surgery at our institution. For each patient, the time of presentation to the ED and the time surgery was performed were recorded, from which the "time to surgery interval" or "interval" was derived. These 100 patients were then stratified according to whether or not a medical consultant requested further preoperative medical testing, and the interval for the two groups was calculated. Further, the results of the testing and the actions that followed were recorded.

Results: The mean "interval" for all 100 patients was 1.79 days. There were 77 patients for whom no specialized preoperative testing was performed. Their mean "interval" was 1.66. For the 23 patients who underwent testing (cardiac enzyme series, 1; ICD interrogation, 1; stress testing, 3; and echocardiography, 18), the mean "interval" was 2.22 ($P = 0.016$). In no instances were any specific preoperative interventions taken in response to the test results.

Conclusion: Preoperative testing for patients with low-energy hip fractures is associated with an increased time to surgery of more than one-half day and, on average, subjects these patients to an "interval" of greater than 2 days (a threshold previously linked to increased risk of mortality). Despite that investment of time, in none of the patients was any substantial clinical intervention undertaken directly in response to the test results. That zero rate of clinical intervention may be related, in part, to the relatively benign results obtained. We conclude that patient care may be improved by more rigorous criteria regarding testing—guided by results that would lead to treatment change—or by more expedited use of tests, all to prevent unnecessary surgical delay.

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Transfusion Practices in Geriatric Hip Fractures: A Survey of Orthopaedic Traumatologists and Residents

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Background/Purpose: Recent evidence suggests that a restrictive strategy of transfusion has equivalent or improved outcomes to a liberal strategy of transfusion in patients following hip fracture, even in the setting of cardiovascular disease. It is unclear if this evidence has changed clinician transfusion practices toward a more restrictive approach in this patient population. This study aims to characterize the transfusion practices among a group of community and academic orthopaedic traumatologists as well as orthopaedic residents.

Methods: Survey questionnaires were sent out to all participants of the AO New England Regional Fracture Summit held in Stowe, Vermont in 2013 as well as all orthopaedic residents at our institution using an Internet-based survey system. A clinical vignette of a fictional hip fracture patient (a 75-year-old female with an unstable 3-part intertrochanteric hip fracture and a history of cardiovascular disease) was presented, and respondents were asked if they would transfuse the patient at five different intervals during the hospital course. Of the five clinical scenarios, only in the final one did the patient's hemoglobin value and symptomatology meet the threshold for transfusion in a restrictive approach.

Results: 42 of 50 orthopaedic traumatologists (84%), and 44 of 60 orthopaedic residents (73%) polled responded to the questionnaire. Based on the clinical vignette provided, 83 of all 86 respondents (96%) favored transfusion in at least one clinical scenario that would not be supported under a restrictive transfusion protocol. When grouped by training level, 39 of 42 orthopaedic traumatolgists (93%) and 44 of 44 orthopaedic residents (100%) elected to transfuse in at least one scenario not supported under a restrictive transfusion protocol. In general, both groups tended toward increasing rates of transfusion as the fictional patient's hemoglobin value dropped, even in the absence of symptoms, with 5 of 86 (6%) electing to transfuse at a hemoglobin value of 9.5, 38 of 86 (44%) at hemoglobin 8.5, and 70 of 86 (81%) at hemoglobin 7.1.

Conclusion: Despite evidence supporting the use of a restrictive transfusion protocol in the management of postoperative hip fracture patients, it has been our experience that these patients often are transfused prior to reaching a restrictive transfusion threshold. We polled orthopaedic trauma experts and orthopaedic residents at a major teaching hospital to see if they would take a restrictive or permissive approach. Among those polled, there was a near-uniform permissive approach to transfusion. The motivation for permissive transfusion strategy among clinicians was not the subject of this investigation, and further study is needed to elucidate what factors may play a role in influencing this decision.

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The Utility of Injury Severity Indices in the High-Energy Geriatric Trauma Population with High-Mortality Orthopaedic Injuries

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Background/Purpose: Injury severity indices (injury severity score [ISS], new injury severity score [NISS], revised trauma score [RTS], and trauma score–injury severity score [TRISS]) have been devised to better characterize injury severity and predict outcomes in the general trauma population. Their usefulness in the geriatric population is less clear as preexisting conditions (PECs) have been shown to significantly affect mortality and these indices do not take these into consideration. We sought to evaluate the predictive ability of the above injury indices in high-energy geriatric trauma patients (HE-GTPs) with high-mortality orthopaedic injuries to better understand if anatomic and/or physiologic parameters should be taken into consideration when devising new injury severity indices in this elder population.

Methods: We conducted a retrospective review of prospectively collected data entered into the North Carolina Trauma Registry for all GTPs (age ≥55 years) who presented to our Level I trauma center from 2008 to 2011. High-energy mechanisms of injury were defined as falls from height, motor vehicle and motorcycle crashes, and pedestrians struck by motor vehicles. We identified 1605 HE-GTPs for which the overall mortality rate was 7.0%. We identified extremity, shoulder girdle, and pelvic/sacral fractures that had a mortality rate greater than 7.0% and labeled these as high-mortality orthopaedic fractures. We found 556 HE-GTPs who met the criteria for high-mortality orthopaedic fractures and used this cohort to compare the ability of the ISS, NISS, RTS, and TRISS to predict inpatient mortality using receiver operating characteristic (ROC) curves.

Results: The mean age of our cohort was 66.5 ± 9.7 years and had a mortality rate of 10.6%. High-mortality orthopaedic fractures included (mortality %): clavicle (13.6%), scapula (14.5%), humerus (14.5%), proximal ulna/radius (11.8%), distal radius (8.4%), femur (13.7%), patella (12.2%), tibial shaft (11.5%), pelvis (12.3%), and sacrum (14.5%). The ability of ISS (area under curve [AUC]: 0.769), NISS (AUC: 0.776), and RTS (AUC: 0.752) to predict mortality was graded as fair (AUC range, 0.70-0.80) and there was no difference among these indices. The ability of TRISS (AUC: 0.860) to predict mortality was graded as good (AUC range, 0.81-0.9) and was significantly better than the ISS (P <0.01), NISS (P = 0.01), and RTS (P <0.01). TRISS predicted 86% of deaths at its most predictive value of 0.87. In contrast, ISS, NISS, and RTS only predicted 67.8%, 74.6%, and 62.7% of deaths at their most predictive values of 27, 27, and 7.55, respectively.

Conclusion: In the high-energy geriatric trauma population with high-mortality orthopaedic fractures, TRISS outperforms ISS, NISS, and RTS in the ability to predict inpatient mortality. TRISS is a combination of an anatomic injury index (ISS) and a physiologic index (RTS), thus both anatomic and physiologic profiles should be included in future studies that aim to develop geriatric trauma specific scoring indices. Since TRISS does not factor in PECs, we feel that new scoring indices that also include PECs are likely to improve the ability to predict inpatient mortality and guide triage to appropriate levels of care.

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Risk Factors for Inpatient Mortality in High-Energy Geriatric Trauma Patients With Shoulder Girdle Fractures

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Background/Purpose: Observational studies involving shoulder girdle fractures (clavicle and/or scapula) have primarily evaluated a younger cohort of patients (age <50 years) and found a high incidence of associated traumatic injuries but minimal correlation with mortality. We sought to evaluate shoulder girdle fractures (+ShG Fx) in high-energy geriatric trauma patients (HE-GTPs) and compare them to a similar cohort of patients without shoulder girldle fractures (–ShG Fx) to determine differences in injury profile and inpatient mortality.

Methods: We conducted a retrospective review of prospectively collected data entered into the North Carolina Trauma Registry for all geriatric trauma patients (age ≥55 years) who presented to our Level I trauma center from 2008 to 2011. High-energy mechanisms of injury were defined as falls from height, motorcycle and motor vehicle crashes, and pedestrians struck by motor vehicles. We identified 1605 HE-GTPs of whom 139 (8.7%) had +ShG Fx and 1466 (91.3%) had –ShG Fx. We performed univariate analysis to compare inpatient mortality rates for both cohorts based on mechanism of injury and associated traumatic injuries. We used multivariate logistic regression analysis to determine which traumatic injuries were drivers of inpatient mortality for +ShG Fx.

Results: The overall mortality rate for +ShG Fx was 2.1 times higher than patients with –ShG Fx (13.7% vs 6.4%, P <0.01); however, multivariate analysis showed that +ShG Fx was not an independent risk factor for mortality (odds ratio [OR] 1.2, P = 0.03). In all HE-GTPs, mortality was driven by thoracic injuries (OR 1.4, P <0.01), abdominal/pelvic organ injuries (OR 1.6, P <0.01), injury to major blood vessels (OR 2.7, P <0.01), and intracranial injuries (OR 3.4, P <0.01). Mean injury severity scores were higher for +ShG Fx compared to –ShG Fx (23.4 ± 10.6 vs 12.5 ± 10.8, P <0.01). Correspondingly, +ShG Fx had an increased incidence of extremity and pelvic/sacral fractures as well as intracranial, thoracic, abdominal/pelvic organ, and major blood vessel injury (P <0.05). Mortality rates were found to be significantly higher for +ShG Fx with concomitant pelvic/sacral fractures (24.2% vs 15.3%, P <0.01) and intracranial injuries (27.1% vs 14.0%, P <0.01). Multivariate analysis revealed that the significant drivers of mortality in +ShG Fx were abdominal/pelvic organ injury (OR 2.4, P = 0.03) and intracranial injury (OR 4.4, P <0.01). +ShG Fxs were 5.4 times more likely than –ShG Fxs to sustain a combined intracranial and pelvic/abdominal organ injury (10.8% vs 2.0%, P <0.01) and these patients had a mortality rate of 46.7%.

Conclusion: HE-GTPs with +ShG Fx have a higher incidence of mortality than those –ShG Fx, which is in contrast to recent studies looking at these injuries in young adults. However, +ShG Fx is not an independent risk factor for mortality. +ShG Fxs have an increased incidence of associated traumatic injuries involving many different organ systems/body regions and the risk factors contributing to increased inpatient mortality in this cohort are abdominal/pelvic organ injuries and intracranial injuries. The presence of +ShG Fx in HE-

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GTPs, which is readily evaluated on injury chest radiographs, warrants thorough evaluation for associated traumatic injuries, particularly intracranial and abdominal/pelvic injuries, and appropriate triage to monitored settings given the high-mortality rate of this cohort.

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Geriatric Hip Fractures and Intra-Hospital Testing: Predicting Costs Utilizing the ASA Score

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Background/Purpose: Surgical fixation of low-energy hip fractures in the elderly is a common orthopaedic procedure that is expected to increase in frequency. As America moves toward alternative systems of payment in which providers and hospitals will be paid a singular amount for care of a patient or injury, it is pivotal that orthopaedic trauma surgeons better understand patient factors that influence intra-hospital testing. Prior data have demonstrated the utility of the American Society of Anesthesiologists (ASA) physical status classification score in predicting postoperative length of stay (LOS) in geriatric hip fractures. This study goes further in exploring the potential use of the ASA score in predicting hospital resources utilized by geriatric hip fracture patients during their perioperative hospital admission.

Methods: From January 1, 2000 to December 31, 2009, all patients over the age of 60 years who presented to the only Level I trauma center in a large metropolitan area with an isolated low-energy hip fracture were reviewed. A total of 720 patients were identified. These patients' charts were reviewed and information was gleaned for 550 complete patients including gender, height, weight, body mass index, ASA classification, and medical comorbidities. Intra-hospital tests/procedures for these 550 patients and respective costs were obtained from the institution's financial services department. The tests/procedures for each patient were provided at the CPT code level with associated costs for each test. The CPT codes were broken into six different groups based on Medicare categories: evaluation and management, anesthesia, surgery, radiology, pathology and laboratory, and medicine. Analysis of variance was conducted to explore the association of ASA with the number of hospital tests as well as the costs of these tests.

Result: For the 550 patients, there was a significant association between ASA score and number of total hospital tests (P <0.001) and total charges associated with these tests (P = 0.001):

ASA Score (n)	No. Postoperative Tests	Cost of Postoperative Tests
1 (1)	14.00	$ 7,075
2 (58)	15.03	$10,098
3 (371)	21.39	$10,996
4 (118)	29.15	$13,364

Furthermore, within the six Medicare categories of CPT codes, there were significant associations between ASA score and number of postoperative tests in evaluation and management (P <0.001), surgery (P <0.001), radiology/imaging (P = 0.002), and medicine (P <0.001).

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Conclusion: In order to better prepare for payment reform, it is critical to develop a tool that not only allows prediction of LOS, but also offers insight into the resources that will be utilized during a given LOS. Orthopaedic trauma surgeons should consider utilizing the ASA score in thinking about resource management for patients with hip fractures.

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Periprosthetic Femur Fractures: 1-Year Mortality Rates for Open Reduction and Internal Fixation and Revision Arthroplasty

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Background/Purpose: Periprosthetic femur fractures (PPFFx) following total hip arthroplasty are complex injuries that are increasing in incidence. Patients with these injuries have high mortality rates, with some reports showing mortality rates approaching those of hip fracture patients. There are little data available, however, describing comparative mortality outcomes for these patients according to method of surgical treatment. The purpose of our study was to compare the survivorship for patients with Vancouver B PPFFx treated with open reduction and internal fixation (ORIF) versus revision arthroplasty, with subgroup analysis of Vancouver B1 and B2 fractures.

Methods: We performed an IRB-approved retrospective review of all patients who underwent surgical treatment for Vancouver B PPFFx at our institutions between 2003 and 2011. Patients were categorized into 2 treatment groups: ORIF or revision arthroplasty. Subgroup analysis of patients treated for Vancouver B1 and B2 fractures was performed. The primary outcome measure was survivorship as identified by the Social Security Death Index and analyzed using the Kaplan-Meier method. The secondary outcome measure was the incidence of major complications.

Results: 122 of 158 identified patients with Vancouver B PPFFx met our inclusion criteria for further analysis. The mean age was 75.7 ± 13.2, with 70 (57%) women. There were no significant cohort differences by age, sex, or Charlson comorbidity index between patients who underwent surgical treatment with ORIF versus revision arthroplasty. The mortality rate at 1 year for patients treated for Vancouver B PPFFx was 13.1%. American Society of Anesthesiologists (ASA) class was highly predictive of mortality ($P = 0.001$). Survivorship, as measured by the Kaplan-Meier method, was significantly decreased for patients treated with ORIF as compared to those treated with revision arthroplasty ($P = 0.04$). In patients ≥79 years old, poor survivorship outcomes persisted in patients treated with ORIF while treatment with revision arthroplasty exerted a protective effect on survivorship. The mortality rate at 1 year for patients treated for Vancouver B2 PPFFx was 15.3%. Survivorship for patients with Vancouver B2 fractures treated with ORIF was significantly decreased as compared to those treated with revision arthroplasty ($P = 0.006$). The overall complication rate was 41.8%, with 25.4% of patients experiencing major complications. The return to operating room rate was 17.2%. The Vancouver B2 revision arthroplasty cohort had a significantly greater number of overall complications (48.8%) and major complications (34.9%) than the Vancouver B2 ORIF cohort (20.6% and 10.3%, $P = 0.04$ and $P = 0.005$, respectively).

Conclusion: Patients with Vancouver B PPFFx treated with ORIF have significantly decreased survival compared to revision arthroplasty counterparts. In patients ≥79 years old, treatment with revision arthroplasty potentiates survival benefits. Patients with Vancouver

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B2 PPFFx treated with ORIF have highly significantly decreased survival compared to revision arthroplasty counterparts. Despite clear survival benefits, consideration for revision arthroplasty should be balanced with the significantly increased risk of major complications which often result in reoperation.

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Retrospective Comparison of Short Versus Long Cephalomedullary Nails for the Treatment of Unstable Intertrochanteric Fractures

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Purpose: The purpose of this study was to compare perioperative measures and postoperative orthopaedic complications between patients who underwent short and long cephalomedullary nails for the treatment of unstable intertrochanteric fractures. Perioperative measures studied included surgical time, estimated blood loss (EBL), and fluoroscopy time. Postoperative orthopaedic complications studied included infection, screw cut-out, periprosthetic femur fracture, and hardware failure.

Methods: The clinical and radiographic records of 505 consecutive patients presenting with intertrochanteric fractures between 2006 and 2010 were reviewed retrospectively. Patients were included if they had an unstable intertrochanteric fracture treated with cephalomedullary nail. Patients were excluded if they had subtrochanteric fracture or if they had inadequate follow-up. The Wilcoxon two-sample test was used to compare perioperative measures and the χ^2 test was used to compare postoperative orthopaedic complications between patients who underwent short and long cephalomedullary nails for the treatment of unstable intertrochanteric fractures.

Results: 310 patients were treated with linear compression cephalomedullary nails during the study period and 206 patients had adequate follow-up for inclusion in the study. Mean radiographic follow-up was 5 months. 88 patients (42.7%) were treated with short nail and 118 patients (57.3%) were treated with long nail during the study period. Demographics were similar between the two groups. Surgical time was shorter in the short nail group (66.9 vs 83.6 minutes, $P = 0.001$). Fluoroscopy time was shorter in the short nail group (106.1 vs 141.4 seconds, $P = 0.001$). EBL was less in the short nail group (176.4 vs 214.1 mL, $P = 0.042$). Infection rate was similar between the two groups. There was one implant failure in the short group and one implant failure in the long group ($P = 0.999$). There were six screw cut-outs in the long nail group (5.1%) and none in the short group ($P = 0.039$). There were seven periprosthetic femur fractures (8.0%) in the short nail group and none in the long group ($P = 0.002$).

Conclusion: This study demonstrates a similar overall rate of orthopaedic complications between short and long cephalomedullary nails for the treatment of unstable intertrochanteric fracture. These results confirm the suspected advantages of short cephalomedullary nails including faster surgery, less blood loss, and less radiation exposure. There were no screw cut-outs in the short nail group and there were no femur fractures in the long nail group. There were more femoral shaft fractures in short nails, and this remains high despite implant design changes. The higher screw cut-out rate in long nails may be from increased rigidity of the construct distally being transferred proximally.

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Cost-Effective Analysis of an Implantable Hip Strengthening Device Compared to Bisphosphonates for Reducing Contralateral Hip Fractures in "At-Risk" Patients

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Purpose: This study was a cost-effectiveness analysis of a proposed hip strengthening device placed contralaterally at the time of index hip fracture. The hypothesis was that the device (assumed to be either 90% or 100% effective in preventing a contralateral hip fracture due to a fall to the side) would be more economical over 10 years compared to either no treatment or bisphosphonate therapy.

Methods: The cost-effectiveness was analyzed for procedures used to address secondary contralateral hip fractures following initial hip fractures. The cost per quality-adjusted life year (QALY) gained was evaluated based on health utility scores that were obtained from a review of utility values for osteoporotic health states and post–hip fracture health states. Prophylaxis intervention costs were calculated and compared to intervention costs with no treatment, treatment with pharmaceutical drugs, and a combination of drugs and the prophylactic device. Cost-utility ratios were estimated in a hypothetical cohort aged 75 years, for a period of 10 years, the "no treatment" contralateral second hip fracture rate being 12%. Total cost of intervention was inclusive of all direct costs involved; the cost of the device or drugs and other services during the treatment period such as dual-energy x-ray absorptiometry (DXA) scans, annual physician visits, etc. The average cost of the implantable device treatment (with an assumed efficacy of either 90% or 100%) was assumed to be a one-time amount of $10,000 (including device, surgeon, hospital, recovery, etc) since this fixation method will be a single surgical event. The average cost of drugs at their maximum efficacy was $1000 per year. A treatment method to prevent hip fractures is cost-effective if the additional cost per QALY gained is equal to or below a threshold value of $50,000.

Results: The results of the analysis are presented in Table 1. This evaluation confirmed the cost-effectiveness of the device over a period of 10 years, and also further implied that the device was more economical when compared to treatment with pharmaceutical drugs over only 5 years. This analysis also implied that when the device was used along with bisphosphonate drugs, the costs remained below the threshold value ($50,000) and therefore were cost-effective.

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Table 1. Cost per QALY of various treatment methods to prevent hip fractures, a 2- to 10-year analysis

Number of Years	Implantable device 100% efficacy (zero fractures)	Implantable device 90% efficacy (10% of expected fractures)	Implantable device used with bisphosphonate drugs 100% efficacy	Bisphosphonate drugs alone 40% efficacy (60% of expected fractures)
0-2	$38,460	$41,670	$37,435	$19,800
0-5	$14,925	$16,670	$20,708	$24,500
0-10	$5000	$6670	$9865	$16,215

Conclusion: A permanently implantable device can maintain efficacy in preventing hip fractures with decreasing costs over longer time periods when compared to no treatment or treatment with bisphosphonate drugs.

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Radiographic Predictors of Screw Cut-Out for Intertrochanteric Fractures Treated With Linear Compression Cephalomedullary Nails

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Background/Purpose: Screw cut-out of the femoral head is the most common failure mode with implants used for fixation of intertrochanteric hip fractures. Radiographic predictors such as Baumgaertner's tip to apex distance (TAD) and Parker's ratio method (PRM) for lag screw placement have been used to evaluate lag screw position within the femoral head. With continuing changes in implant design, the purpose of this study was to evaluate TAD and PRM as radiographic predictors of screw cut-out in the latest generation of cephalomedullary nails.

Methods: A retrospective chart review of consecutive patients presenting with intertrochanteric fractures between 2008 and 2010 was performed. TAD and PRM ratios were measured on immediate postoperative AP and lateral radiographs for each patient. Single and multiple logistic regressions and *t* tests were used for analysis of screw cut-out.

Results: 176 patients were treated with long linear compression cephalomedullary nails during the study period and 99 had more than 57 days follow-up for inclusion. Mean radiographic follow-up was 10 months. Six patients (6.1%) had screw cut-out at 10, 14, 31, 32, 33, and 57 days postoperatively. TAD was not demonstrably associated with increased risk of failure (P >0.146). Increased AP ratio was significantly associated with risk of failure (P <0.003, odds ratio [OR] = 1.386 [95% confidence interval [CI] = 1.125, 1.707]; nonfailures 49.0 ± 7.9%, failures 67.6 ± 5.2%). Increased lateral ratio was significantly associated with risk of failure (P <0.028, OR = 1.138 [95% CI = 1.015, 1.275]; nonfailures 49.7 ± 8.7%, failures 58.2 ± 8.5%). When considered in a multiple logistic regression, only the AP ratio was significantly (and positively) associated with risk of failure (P =0.004, OR = 1.393 [95% CI = 1.112, 1.745]) and neither TAD (P = 0.764) nor lateral ratio (P = 0.710) were demonstrably associated with risk of failure.

Conclusion: Screw cut-out in the most recent generation of cephalomedullary implants does not appear to be as associated with increased TAD as in previous generations of cephalomedullary nails. AP ratio is, of the three, the most helpful measurement in predicting screw cut-out.

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Acetabulum Fractures in Elderly Patients: Which Injury and Treatment Characteristics Are Associated With the Best Outcomes?

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Background/Purpose: In the United States, the elderly population is rapidly increasing. Acetabulum fractures are life-altering and possibly life-threatening injuries for these patients. Few prior studies have addressed acetabulum fractures in this population, often subject to treatment challenges including poor bone quality, preexisting arthrosis, and underlying medical conditions. The best course of action would promote efficient return to ambulation while minimizing complications. The purpose of this study is to review a large series of acetabulum fractures in this group and to identify favorable injury and treatment characteristics.

Methods: Records of 171 patients over 60 years of age with acetabulum fractures were reviewed. This included 124 men and 47 women. Mechanism of injury was low-energy fall in 85 and high-energy mechanisms in 86, most commonly motor vehicle collision (n = 69). Mean age was 71.2 years (range, 60-94). Fracture patterns included OTA 62A (n = 53), 62B (n = 42), 62C (n = 76) with associated both-column (ABC) in 58 (34%), and posterior wall in 30 (18%), most common. Treatment characteristics, complications, hospital stay, and secondary procedures were documented. Early complications included infections (wound, urinary, other), pneumonia, deep venous thrombosis (DVT), and pulmonary embolism. Sequential radiographs were reviewed for arthrosis and osteonecrosis.

Results: Open reduction and internal fixation (ORIF) was performed in 91 patients (53%): 53 Kocher-Langenbeck and 38 ilioinguinal approaches. Posterior fracture dislocations were most likely to be treated surgically. One patient had a primary total hip arthroplasty (THA). Seven nonoperative patients died within the first few days of hospitalization, and the overall 1-year mortality rate was 8.8% (n = 15). Other complications occurred in 24% of all patients. Nonoperatively treated patients had less pneumonia: 7.0% versus 14.3% in surgical patients ($P = 0.10$). However, nonoperative patients had more DVTs (14.1% vs 8.8%, $P = 0.29$), resulting in no differences in total complication rates between the two groups. The highest complication rate was seen after ilioinguinal approach (29%). Mean hospital stay was longer in patients treated with ORIF: 15.3 days versus 10.2 ($P = 0.002$). 51 patients were over 75 years of age. Seven of them had ORIF with mean blood loss of 830 cc, and a 71% complication rate. The majority of patients in this group had ABC patterns, and the THA conversion rate after nonoperative management was 4.5%. Secondary THA was done in 9.8% of all patients at mean 31 months after injury, with 44% of these occurring within 1 year after injury. 19% of patients with late THA had initial nonoperative care; thus 15.4% of operative and 4.2% of nonoperative patients had secondary THA ($P = 0.013$).

Conclusion: Half of the acetabulum fractures in patients over 60 years of age were due to low-energy falls and were treated nonoperatively with low rate of secondary THA. However, unstable posterior patterns with associated dislocations were more often treated surgically, likely to avoid prolonged bed rest and traction. Hospital stays in this group were longer and more developed pneumonia. Complications and large surgical blood loss were most com-

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mon after ilioinguinal approaches. Conversion to THA was more likely after initial ORIF, suggesting the need for careful patient selection for ORIF and warranting further study into alternative treatment options including less-invasive fixation or acute THA.

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•Dynamic Locked Plating of Comminuted Distal Femur Fractures: A Matched Cohort Study

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Background/Purpose: Locked bridge plating of comminuted supracondylar femur fractures has become extremely common. Despite promising results of early series, recent data from multiple centers have demonstrated nonunion rates between 10% and 20%. The stiffness of these implants and the eccentric position likely contribute to insufficient and asymmetric fracture site motion and nonunion. A newer concept of "dynamic" locked plating, which allows for some toggle at the near cortex between the plate and bone, has been proposed to provide an improved mechanical environment for callus formation. Our hypothesis was that dynamic locked plating constructs allows for greater callus formation and higher union rates than standard hybrid locked plating constructs.

Methods: 14 patients with comminuted supracondylar femur fractures amenable to bridge plating technique were treated with dynamic locked plating constructs between November 2009 and October 2011. Two patients were excluded because they did not have follow-up radiographs. Of the remaining 12 patients (average age, 60 years; range, 30-83), 5 sustained high-energy mechanisms and 7 sustained low-energy falls from standing height. The near cortices of diaphyseal screws (all locked) were drilled to 1 mm larger than the major diameter of the screw, allowing for 0.5 mm of circumferential clearance and "toggle". The far cortices were drilled in standard fashion to the screw minor diameter. Patients were followed prospectively at routine intervals with clinical examination and orthogonal radiographs. Weight bearing was advanced at 6 to 8 weeks postoperatively based on clinical and radiographic evidence of fracture healing. Painless weight bearing and radiographic bridging of 3 of 4 cortices defined fracture union. Patients in the dynamic plating group were matched to patients who underwent standard hybrid locked plating by working length (within one hole) and OTA classification. All patients were followed to union or development of nonunion (average 10 months). Coronal and sagittal plane alignment was measured on the immediate postoperative and final radiographs to determine change in fracture reduction or fixation failure. Three observers, blinded to fixation type, made callus measurements on a 4-point ordinal scale (0 = none, 1 = minimal, 2 = moderate, 3 = robust). Test and interobserver reliability measures were performed. Average and standard deviation of the callus scores were calculated for each group.

Results: The mean callus score for the dynamic group was significantly greater (2.0; standard deviation [SD], 0.7) compared to the control group (1.3; SD, 0.8, $P = 0.048$). Two-way mixed intraclass correlation analysis showed substantial agreement among observers in both consistency (0.724) and absolute score (0.734). In the dynamic plating group, one patient failed to heal after the index procedure, versus three in the control group ($P = 0.59$). The dynamic group had a mean change in alignment of 0.5° (SD 2.6) compared to 0.6 (SD, 3.0) for the control group ($P = 0.9$), and there were no fixation failures in the dynamic group. The groups did not differ significantly based on age, gender, mechanism, smoking status, diabetic status, open/closed fracture, or a history of total knee arthroplasty (P >0.05 for all).

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Conclusion: Recent data demonstrate high nonunion rates for locked plating of supracondylar femur fractures. This has been attributed to overly stiff constructs and eccentric fixation. Overdrilling the near cortex is a technically simple adaptation using standard implants that creates a dynamic construct, which allows for increased axial motion, particularly at the near cortex. This technique appears to be safe (no fixation failures), promotes abundant callus formation, and may decrease nonunion rates seen with standard locked plating.

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Management of Closed Femur Fractures with the SIGN Intramedullary Nail in Two Developing African Countries

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Purpose: The Surgical Implant Generation Network (SIGN) intramedullary nail was designed for use in developing settings that often lack fluoroscopy or power instrumentation. Our purpose was to evaluate the clinical and radiographic outcomes of closed femoral shaft fractures fixed with the SIGN nail in two developing African countries.

Methods: Data from the SIGN online database was reviewed for all closed femur fractures treated with the SIGN nail at two mission hospitals in sub-Saharan Africa. Demographics, time to surgery, fracture classification (AO/OTA), antegrade versus retrograde approach, open versus closed reduction, number of follow-ups, time to union, and complications were recorded. Only patients with at least one follow-up visit were included in the analysis.

Results: Between September 2008 and November 2012, 471 patients were treated with the SIGN nail for closed femur fractures. Of these, 235 patients (240 fractures) returned for at least one postoperative visit. Average age was 43.3 years (Range 14-87). Average time from injury to fracture fixation was 6.1 days (Range 0-60 days). Nails were placed antegrade in 137 fractures (57%) and retrograde in 103 fractures (43%). Open reduction was performed in 208 cases (87%). Average length of follow-up was 99.7 days (range 15-838 days). Average number of follow-up visits per patient was 1.6. Average time to union was 96.1 days (Range 21-707 days) for those patients (154 fractures, 64%) with enough follow-up to show radiographic union. Overall, 26 complications occurred in 23 patients (9.6%). The most common complication after retrograde nailing was knee stiffness, representing 7 of 14 complications (50%) in this group. Varus mal-union of proximal femoral shaft fractures accounted for 5 of 12 complications (42%) after antegrade nailing. Other complications included deep infection in four patients (1.5%), nonunion in three patients (1%), and peri-prosthetic fractures at the proximal tip of the nail after retrograde nailing in two patients (0.8%). Revision surgery was performed in 12 patients (5%).

Conclusion: Closed femur fractures can be managed successfully in developing countries using the SIGN nail with acceptable rates of complications and reoperation. Predictable complications related to surgical approach and fracture location were observed. Although radiographic union was confirmed in only 64% of fractures, many patients were lost to follow-up prior to the time of expected radiographic union. Known geographic and financial barriers common in the developing world create a disincentive for asymptomatic patients to return for routine follow-up visits. Low rates of deep infection and nonunion were seen despite the fact that open reduction was performed in the vast majority of cases. These favorable outcomes further support the utility of the SIGN nail for intramedullary fixation of closed femur fractures in the developing world.

See pages 91 - 132 for financial disclosure information.

Is Prophylactic Intramedullary Nailing for Bisphosphonate-Associated Incomplete Femoral Fractures a Cost-Effective Treatment Strategy?

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Background/Purpose: Patients who report long-term bisphosphonate use and present with radiographic evidence of an incomplete subtrochanteric femur fracture and pain are generally at a 15% risk for fracture progression to completion. Although nonoperative treatment can lead to fracture healing, it has been demonstrated that a prophylactic intramedullary nail (IMN) inserted into the femur has a higher success rate. A cost-effectiveness analysis (CEA) is performed to evaluate and compare costs and outcomes of operative versus non-operative treatment for incomplete bisphosphonate-associated femoral fractures (BAFFs).

Methods: A Markov decision process model (MDP) was constructed to represent key decisions and outcomes relevant to our CEA. We performed a retrospective analysis on a cohort of patients diagnosed with BAFFs in order to determine relevant states, decisions, and probabilities of chance events; probability data were supplemented from other study cohorts or the literature where appropriate. The costs for operative and nonoperative treatments were calculated from associated device, implant, and medication price estimates at our institution. Quality-adjusted life years (QALYs) were estimated using published data on similar fractures. An average cost-effectiveness ratio (ACER) was then calculated for each outcome measure.

Results: Patients diagnosed with incomplete BAFFs and treated operatively were found to have superior outcomes across most measures. Patients who underwent prophylactic IM nailing cost an estimated average of $21K more than those who were treated nonoperatively, taking into account the cost of all modalities. The ACERs for each measure are as follows: $4800 per point reduction in one's mean Standardized Dysfunction Index, a component of the Short Musculoskeletal Functional Assessment; $800 to increase one's chances of averting a fracture by 1%; and an estimated $7800 per QALY saved within the analytic horizon of 2 years from the date of presentation. An exception to this trend was the outcome of days spent in the hospital—these were generally greater for patients treated with prophylactic IMNs, despite accounting for time added for recovery following the repair of a complete fracture if it were to occur. Furthermore, our model predicts that extending the analytic horizon out to 10 years should correspond to changes in ACERs that further favor prophylactic surgery assuming the following: consistent or greater probability of incomplete BAFFs progressing to completion, consistent or greater success rates of prophylactic IMNs corresponding to a higher average quality of life, and the accumulation of alternate medication costs among nonoperative patients.

Conclusion: Patients diagnosed with incomplete BAFFs represent a relatively small population, and may elect to forego prophylactic surgery on the basis of higher costs and perceived risk. The results from our analysis reinforce the observation that operative treatment is generally the superior option leading to fracture healing in the short term, and we recommend that patients and health-care providers consider the use of cost-effectiveness ratios as a factor in the decision-making process.

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Femoral Neck Fracture Reduction: Is Our Interpretation of Intraoperative Fluoroscopy Accurate?

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Background/Purpose: An anatomic reduction has been cited in many studies as the most important predictor of a successful outcome in femoral neck fracture treatment. Controversy exists as to whether an open approach is necessary to determine whether an anatomic reduction has been achieved in this area. We sought to answer this question by determining whether experimentally produced typical malreductions were visible fluoroscopically to fellowship-trained trauma surgeons. Our hypothesis was that these experts would not be able to identify 5° varus or retrotorsion malreductions by viewing standard AP and lateral fluoroscopic imaging.

Methods: 10 human fresh-frozen femoral cadaveric specimens were osteotomized in a consistent fashion at the femoral neck level using a thin osteotomy blade. 5° varus malreductions and 5° retrotorsion malreductions were stabilized using wire fixation. AP and lateral hip fluoroscopic views of these malreductions were saved as couplets. These malreduced radiographic couplets were combined with radiographic couplets of osteotomized, anatomically stabilized specimens in random order using PowerPoint format. Experts were then asked to determine whether or not the radiographic couplets revealed an anatomically reduced fracture. Inter- and intraobserver reliabilities were evaluated.

Results: Fellowship-trained traumatologists identified a 5° malreduction 67% of the time. Intraclass correlation coefficient revealed fair interobserver reliability with an alpha reliability statistic of 0.53. Intraobserver reliability across all four observers yielded an alpha statistic of 0.68, indicating consistency in observer's evaluation of identical images at separate viewings.

Conclusion: Our hypothesis was rejected. Fellowship-trained traumatologists were able to discern 5° malreductions of femoral neck fractures viewing only AP and lateral fluoroscopic images two-thirds of the time on average. Some were accurate over 90% of the time, revealing an individual difference in ability to discern displacement on fluoroscopic imaging. Based on these findings, it appears that an open approach is not always necessary to determine whether a femoral neck fracture has been anatomically reduced.

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Retrograde Versus Antegrade Femoral Nailing of Gunshot Femur Fractures

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Background/Purpose: The use of retrograde nailing for gunshot femur fractures is controversial because of concerns about knee sepsis following this procedure in which the knee joint is entered to introduce the nail into the canal. Previous clinical series using this technique have not shown knee sepsis. To our knowledge, a comparison of antegrade to retrograde nailing for the treatment of gunshot femur fractures has not been done.

Methods: The prospective trauma database was retrospectively reviewed from 1999 to 2012 for those with a diagnosis of gunshot and femur fracture. Records review for those with OTA fracture classification type 32 (femoral shaft fracture) secondary to gunshot and treated with either a retrograde or antegrade femoral nailing were included. Records and radiographs were reviewed, as well as attempts to contact every patient. The records were reviewed for operative treatment (procedure, anesthesia time, operative time, and estimated blood loss). Clinical outpatient records were reviewed to determine mechanism of injury, history of injury, physical exam to include extremity nerve and vascular status, employment status, hospitalization stay, and clinic follow-up. Temporizing measures, such as a skeletal traction pin, or temporary external fixation were noted. Radiographic results were reviewed. For inclusion, initial radiographs and subsequent radiographs up to the point of demonstrating fracture union needed to be available for review. Attempts to contact every patient were made. Knee sepsis was defined as a return to the operating room for débridement and irrigation or aspiration of the knee with positive culture results.

Results: There were 81 patients who sustained gunshot femoral shaft fractures treated with intramedullary nailing (53 retrograde and 28 antegrade). No significant difference was found between the two groups with regard to operative time or blood loss. Six patients had vascular injury, 2 in the antegrade group and 4 in the retrograde group. Two patients in the retrograde group had superficial bullet entry wound infections, and one patient had a deep infection in the antegrade group. No cases of knee sepsis were found. Of the 81 patients, 24 of 28 (86%) in the antegrade group and 43 of 53 (81%) in the retrograde group could be contacted for follow-up. Average follow-up was 40.7 months for the retrograde group and 26.3 months for the antegrade group. Nonunion occurred in 3 patients in each group: antegrade (12%) and retrograde (7%).

Conclusion: To our knowledge, this is the first study to directly compare retrograde to antegrade nailing of gunshot femur fractures. Immediate retrograde nailing is as safe as antegrade nailing for the treatment of gunshot femur fractures.

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Implant and Radiography Decisions in the Treatment of High-Angle "Vertical" Femoral Neck Fractures in Young Adult Patients: An Expert Opinion Survey

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Purpose: Our objective was to identify the current implant and diagnostic imaging choices among experts in orthopaedic traumatology in the treatment of high-energy femoral neck fractures in young adult patients.

Methods: A cross sectional survey was administered to 573 surgeon members of the OTA. We wanted to determine the surgeons' preference for implant and imaging in surgical treatment of a high Pauwels angle femoral neck fracture in a young adult patient (<30 years of age). In addition we wanted to understand the reason this implant was used, if the surgeon felt that reason was clearly supported by the literature, and what imaging studies are routinely obtained to help in making this decision.

Results: 269 surgeons (47%) responded to the survey, with 261 completing all questions. The preferred construct for a vertical (ie, 60° Pauwels angle) femoral neck fracture in a healthy 30-year-old patient was a sliding hip screw with or without anti-rotation screw (45%), parallel cannulated screw with off-axis screw (28%), parallel screw construct (15%), locking proximal femur plate (4%), cephalomedullary nail (4%), and arthroplasty (0.4%). When asked if their chosen construct was clearly supported by the literature 54% agreed/strongly agreed. 70% of surgeons chose their preferred implant because it was "biomechanically most stable." Other reasons for implant choice included: less invasive (7%), fewer complications (7%), and technically easier (6%). No surgeon chose reimbursement as the most important factor for implant decision. Most surgeons required AP pelvis (70%) and standard hip (88%) radiographs prior to surgery. 17% required traction or rotation films while 44% found them helpful but not required. 28% required a CT scan of the hip/pelvis prior to surgery while 59% found them helpful but not required. 20% of surgeons at some point have changed their implant choice during surgical treatment based on intraoperative imaging. When asked if further preoperative imaging would have allowed the intraoperative change in implant choice to be avoided 48% disagreed/strongly disagreed while 15% agreed/strongly agreed. 17% of surgeons stated that they have never deviated from their preoperative construct decision intraoperatively.

Conclusion: Femoral neck fractures in young adult patients are a challenging problem with high rates of failed treatment. Many options for treatment exist and a consensus on the best method remains elusive. Our survey demonstrates the diversity and disagreement among orthopaedic traumatologists for the "best" treatment choice. Our survey shows a divided level of confidence in the current literature and need for further study of this problem.

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In Situ Proximal Femur Positioning and Radiographic Landmark Measurements: How Accurate Are We?

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Background/Purpose: Radiographic measurements of fixed proximal femur fractures allow for quantification of fracture reduction. In situ neck-shaft angle (NSA) and tip-apex distance (TAD) are two common measurements. It is known, however, that operative examinations may be performed with the femur in rotation and/or flexion, rather than viewed in true anterior/posterior (A/P) and medial/lateral (M/L) directions. Thus, there is the potential for measurement error due to these discrepancies. The purpose of this study was to quantify the difference between in situ radiographic measurements and true anatomical angles and distances.

Methods: Radiological assessment of proximal femur analogs fixed with an intramedullary nail followed traditional methods. Measurements included: (1) NSA through 50° of internal rotation to 50° of external rotation, (2) TAD in A/P plane through 50° of internal rotation to 50° of external rotation, (3) TAD in M/L plane through 50° of internal rotation to 50° of external rotation, (4) NSA measurements with 0 to 30° of flexion, and (5) TAD measurements with 0 to 30° of flexion. NSA measurements were recorded in duplicate using both anatomical and implant-specific references. All measurements were taken at 5° increments using either digitized calipers with an accuracy to 0.02 mm throughout full range or an analog goniometer with an accuracy to 0.5° throughout full range. Measurements from each radiograph were compared to true known measurements. Overall correlations of in situ measurements were made using linear regression.

Results: Radiographic measurements were dependent on proximal femur positioning. In situ measurements deviated from true anatomical angles and distances across all but one test group (P <0.05, excluding posterior rotation M/L TAD measurements). As internal or external rotation increased, NSA deviations positively increased (P <<0.05). The opposite correlation was seen during flexion: as flexion increased, measured NSA values decreased (P <<0.05). At maximum experimental angles, measured NSAs deviated 11° on average from true NSA when femoral anatomy was used as the reference (P <<0.05). At these same maximum angles, measured NSAs deviated 9° on average from true NSA when the implant was used as the reference (P << 0.05). Increasing rotation resulted in subsequent increases in A/P TAD measurements: deviation was 5° on average from true A/P TAD at the maximum angles. Despite one of two groups with statistical significance, anterior rotation (P = 0.003) and posterior rotation (P = 0.07) had a negligible effect on M/L TAD measurements, which at the maximum angles only deviated 0.6° on average from true M/L TAD.

Conclusion: When comparing presentation, intraoperative, postoperative, and follow-up radiographs of the supine patient, maintaining the same leg position in each scenario is not plausible. Rotation or flexion of the femur as an aid in fracture reduction results in quantifi-

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able inaccuracies when NSA and TADs are considered. Surgeons should compensate for these discrepancies or only rely on radiographic measurements when taken in the correct manner.

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Incidence of Reoperation Following Internal Fixation of Femoral Neck Fractures in Adults Age 60 Years or Less: A Meta-Analysis

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Purpose: Young adult (age <60 years) femoral neck (FN) fractures are typically the result of vehicle accidents and other high-energy trauma. Internal fixation remains the preferred management strategy, despite potential fracture healing complications. In order to understand the burden of these injuries, we sought to quantify the incidence of reoperation and other patient important complications following internal fixation.

Methods: A systematic literature search was conducted using multiple electronic databases and conference proceedings to identify studies involving the treatment of femoral neck fractures. Studies were included if the subjects were age 60 or less and they had been treated with any type of internal fixation. Studies with ipsilateral femoral shaft fractures were also included. All searching and data abstraction were performed in duplicate. A random effects model was used to quantitatively pool estimates of reoperation, osteonecrosis, and nonunion. All results were stratified based on fracture displacement and presence of ipsilateral femoral shaft fracture.

Results: 1818 titles were identified and 40 studies met inclusion criteria (28 FN only, 12 FN and ipsilateral femoral shaft fracture). Only 5 studies directly compared two fixation options and these studies were too heterogeneous to allow for pooled comparisons of the treatments. A total of 1513 fractures were included in the final analysis. The average mean age in the included studies was 38.7 ± 9.13 years. The overall pooled incidence of reoperation was 17.4% (95% confidence interval [CI]: 13.5-22.1%, $I^2 = 0\%$). The overall incidence of osteonecrosis was 13.0% (95% CI: 11.2-15.1%, $I^2 = 0\%$) and nonunion was 8.3% (95% CI: 5.9-11.5%; $I^2 = 0\%$). Table 1 displays the stratified results based on fracture displacement and ipsilateral shaft fractures.

Outcome	FN, Any Displacement	Displaced FN	Undisplaced FN	FN and Shaft	**Overall**
Reoperation	19.5%	19.0%	6.9%	13.7%	**17.4%**
Osteonecrosis	14.0%	14.6%	6.4%	4.7%	**13.0%**
Nonunion	9.1%	9.6%	5.2%	6.2%	**8.3%**

Conclusion: Young adult FN fractures are a challenging injury. Despite best efforts at surgical fixation, nearly 20% of patient experience a reoperation following internal fixation of their fracture. Furthermore, the functional burden of malunion and fracture shortening are not captured in the present review. Efforts to improve the outcomes of these fractures are necessary, as the current literature is unable to provide strong treatment guidelines.

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A Systematic Approach to Reamed Exchange Nailing for the Treatment of Aseptic Femur Nonunions: A Review of 60 Nonunions in 59 Patients Treated by a Single Surgeon

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Purpose: This study aimed to determine the effectiveness of a systematic approach to exchange nailing for the treatment of femoral nonunions previously treated with an intramedullary nail.

Methods: 60 femoral nonunions in 59 patients who were initially treated with an intramedullary nail were subsequently treated by a single surgeon in a major metropolitan area with a closed intramedullary exchange nail of at least 2 mm larger in diameter with reamed insertion as well as proximal and distal static interlocking. Patients were followed to healing, which was confirmed radiographically as well as clinically by the absence of symptoms indicative of persistent nonunion.

Results: Of 60 femoral nonunions, 9 were lost to follow-up prior to confirmation of fracture union. 51 femoral nonunions were seen throughout their entire clinical course, of which 50 (98%) healed following this systematic approach to femoral exchange nailing. The average time to achieve union was 6 months. 12 of 50 nonunions (24%) required dynamization of which all but one healed. An exchange nail of at least 2 mm larger diameter, static interlocking, use of different manufacturer at time of exchange nailing, correction of underlying metabolic abnormalities, and use of a custom nail in a select number of patients were associated with success.

Conclusion: Use of this systematic approach for treatment of femoral nonunions with exchange nailing has proven to be successful in this largest known series to date by a single surgeon with a 100% healing rate. The systematic approach to exchange nail treatment of femoral nonunions includes: (1) careful patient selection by excluding patients with known infected nonunions and those with partial segmental defects involving greater than 50% of the cortical diameter, (2) increasing the diameter of exchange nail by at least 2 mm, (3) proximal and distal static interlocking at the time of exchange nailing, (4) use of a different manufacturer at time of exchange nailing to change the location or trajectory of interlocking screws, (5) correction of identified metabolic abnormalities, and (6) use of robust interlocking fixation in cases with less stable nonunion locations and a significant mismatch between exchange nail diameter and the cortical diameter at the level of the nonunion.

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Durability of Cephalomedullary Nail Fixation for Treatment of Metastatic Peritrochanteric Femoral Lesions

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Purpose: The optimal approach to the stabilization of the proximal femur in patients with metastatic peritrochanteric femoral lesions is not well established. This study reviewed the durability of cephalomedullary nail fixation of metastatic peritrochanteric femoral lesions and evaluated the causes for failure.

Methods: A retrospective chart review was conducted of patients treated with cephallomedullary nails for metastatic bone disease or myeloma from January 1990 to December 2009 at a single institution. 203 consecutive patients (208 nail procedures; 5 patients had bilateral fixation) with a symptomatic bony metastasis isolated to the peritrochanteric region of the femur were identified. 57 patients presented with an acute displaced fracture and were admitted urgently. Mean age of patients was 59 years and the female:male ratio was 1:1. The most common primary disease associated with the indication for fixation was breast carcinoma (22%), followed by lung carcinoma (21%), renal cell carcinoma (18%), and multiple myeloma/plasmacytoma (9%). In addition to cephallomedullary nailing, 88 patients (43%) underwent curettage of metastatic deposit with cement augmentation based on surgeon preference. Failure was defined as implant breakage and/or loss of fixation requiring reoperation in order to restore the stability of the proximal femur. All demographic data and postoperative details were obtained from the chart. The study was performed in accordance with the IRB.

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Results: The median survival after surgical intervention was 8 months (range, 1-134 months). Fixation was maintained until last follow-up in 191 patients (94%). In the prophylactic nailing group, the failure rate was 9.5% (14 of 148 cases), and in the fracture group the failure rate was 5.3% (3 of 57 cases). Six of 78 patients (8%) who initially underwent curettage/cement augmentation required revision due to disease progression. Median time to failure was 11 months (range, 3-15 months). Failure of fixation was attributed primarily to tumor progression in 42% of cases and hardware failure or loss of fixation in 58% of cases. The failure rate was highest for renal cell carcinoma (6 of 36 cases [17%]). The conversion rate to proximal or total femur endoprosthesis was 6%. The other patients with failed implants were treated with repeat cephalomedullary nailing. One patient who was treated with an intercalary allograft and en bloc resection of renal cell carcinoma developed a nonunion at the distal site and breakage of distal interlocking screw, requiring iliac crest bone grafting, but the original nail remained intact at 4-year follow-up.

Conclusion: Cephalomedullary devices provide adequate fixation with good durability and pain control for most patients with metastatic disease in the peritrochanteric region. Failure rates are at or below 10% even if they are used to treat pathologic fractures. Although lung carcinoma was the second most common primary disease, we observed only one failure in this group, possibly related to poor patient survival. Initial treatment with nail still allows

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for successful conversion to endoprosthesis if tumor progression or hardware failure occurs. Further studies are needed in order to stratify primary disease and predict response to systemic treatment and radiation in order to choose the optimal surgical procedure. Caution may need to be exercised when treating aggressive histologies in the peritrochanteric region with cephalomedullary nails. Curettage of metastatic deposits and concurrent cement augmentation may decelerate disease progression in certain diseases such as renal cell carcinoma. Alternatively, proximal femoral replacement might be considered in such cases.

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Omitting Preoperative Coagulation Screening in Fractured Neck of Femur Patients: Stopping the Financial Cascade?

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Background/Purpose: Departmental fractured neck of femur protocols dictate that all patients admitted with fractured neck of femurs undergo routine preoperative coagulation screening. The Association of Anaesthetists of Great Britain and Ireland (AAGBI) guidelines currently recommend that preoperative coagulation screening be performed only if clinically indicated. This study aims to show that preoperative coagulation screening is an unnecessary investigation in patients not on warfarin or those without a background of coagulopathy. This study further extrapolates the potential wide-reaching financial implication of omitting such screening.

Methods: Prospective data were collected by using an audit pro forma in accordance with the Standardised Audit of Hip Fractures in Europe (SAHFE). All patients who were admitted to our hospital with fractured neck of femurs during a 12-month period from November 2011 to November 2012 were analyzed. Coagulation results, use of vitamin K, and blood products were collected retrospectively from the hospital online reporting system. Patient subgroup analysis was performed for total units used for postoperative blood transfusions, hematoma, gastrointestinal (GI) hemorrhage, and intraoperative blood loss. Extrapolation of potential national financial savings of omitting preoperative coagulation screening was also calculated. A normal coagulation screen was considered to be prothombrin time (PT) 9 to 12 sec, activated partial thromboplastin time (APTT) ≤25 sec, and thrombin time (TT) ≤16 sec. χ^2 tests and independent-sample *t* tests were used for basic statistical analyses. P <0.05 was considered significant.

Results: 811 hip fractures were analyzed between November 2011 and November 2012. Four main patient subgroups (1-4) emerged. Coagulation screening was not performed in 66 patients (8.1%) (1). All of the remaining patients (n = 745) had coagulation studies, of which 77.7% (n = 579) were normal (2) and 22.3% (n = 166) were abnormal. Of these, 39.2% (n = 65) were patients admitted on warfarin (3). The remaining 101 patients had abnormal coagulation studies but were not taking warfarin or known to have a coagulopathy (4). No patient from subgroup 4 had treatment to reverse their abnormal coagulation studies with either vitamin K or blood products. The patient subgroup 4 (n = 101) was statistically compared to both patient subgroup 2 (n = 579) and all other patients (n = 710). There was no difference in intraoperative blood loss (P = 0.89, 0.71), postoperative transfusion (P = 0.34, 0.65), postoperative hematoma formation (P = 0.77, 0.44), or GI hemorrhage (P = 0.76, 0.46), respectively. Nationally, the cost of coagulation screens may vary between $6.20 and $17.22. Annually in the United Kingdom, approximately 77,000 hip fractures occur, of which 5% take warfarin. Omitting one coagulation screen on the remaining 95% could generate an estimated financial saving of between $450,000 and $1.25 million per annum in the United Kingdom.

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Conclusion: This study supports the hypothesis that routine coagulation screening in preoperative neck of femur fracture patients not known to use warfarin or have coagulopathy is unnecessary. Moreover, its omission represents significant cost-saving potential to a health service.

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Quantitative Assessment of Femoral Head Perfusion Following Femoral Neck Fractures: An In Vivo Contrast-Enhanced MRI Study

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Background/Purpose: Compromise of femoral head vascularity and subsequent development of osteonecrosis is a significant concern following femoral neck fractures (FNF). A presumed etiologic cause of this compromise is a decrease in arterial in-flow caused either directly by disruption of the terminal vessels and/or indirectly by tamponade secondary to development of an intra-articular fracture hematoma. In FNF, vascular disruption of the intraosseous nutrient artery and the superior retinacular artery (SRA) is presumed due to the close proximity of those arteries to the femoral neck. Vascular supply from the inferior retinacular artery (IRA) (previously shown to provide significant arterial supply to the entire head) and foveal artery (FA) may be preserved as these arteries are protected by the inferior retinaculum of Weitbrecht (a structure separated from the femoral neck) and the ligament of teres (positioned far from the fracture site), respectively. Furthermore, it has also been established that rotatory and valgus malposition can affect FA blood flow. We aimed to quantify perfusion of the femoral head, using contrast-enhanced MRI, in a patient cohort that presented with FNF at our institution. Our hypothesis is twofold: (1) some perfusion to the femoral head will be maintained despite the FNF due to preservation of the IRA and foveal artery; and (2) only fracture location (subcapital) and angular deformity (valgus malposition and posterior roll-off) will a have a greater negative effect on overall femoral head perfusion.

Methods: 31 patients (mean age, 60 ± 15.6 years; 9 males, 22 females) who presented with acute FNF were included. We obtained fat-suppressed dynamic contrast-enhanced MRI, a technique that provides an estimate of bone perfusion in vivo by imaging uptake of gadolinium (Gd)-DTPA in the femoral head over time. Simultaneous imaging of the injured and uninjured (contra lateral/control) proximal femurs was also acquired using a 1.5-T MRI system with an 8-channel phased-array torso coil. Gd-DTPA was injected at 0.1 mM/kg using a power injector. The DCE MRI sequence used a coronal fat-suppressed 3-dimensional spoiled gradient echo pulse sequence (LAVA) with a temporal resolution of 7 sec/image over 45 time points for a scan time of 6 minutes. The Brix 2-compartment model was used to analyze the DCE MRI uptake curves in the normal and injured femoral head. Regions of interest (ROI) of the entire femoral head were defined and subdivided into quadrants producing time intensity curves using the control side as a reference in each subject. Analysis software was written in house using IDL 8.1 to fit the time intensity curves. Model parameters were averaged for all subjects creating time curves (Figure 1). We subdivided the cohort by fracture characteristics: fracture location, coronal/sagittal displacement, axial translation, and commonly used fracture classifications (Garden, Pauwels angle, and AO/OTA) (Table

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1). Modifications of the classic fracture classification (based on displacement and posterior roll-off) were also used to develop the comparison groups (Table 2). A series of multivariant linear regression models were used to determine the effect of different fracture characteristics on residual perfusion of the injured femoral head.

Results: A significant (P <0.01) decrease in perfusion was noted in the entire injured femoral head when compared to the contralateral side (internal control). Quadrant analysis revealed the most prominent decrease in perfusion in the superomedial quadrant, as well as significantly delayed washout in the injured side as compared to the uninjured side in all quadrants. Despite a significant decrease in perfusion, some blood flow to the femoral head on the injury side was always detected, indicating preservation of some of the arterial system. Comparison of the fracture characteristics groups showed no significant difference in the perfusion of the injured femoral head. We presume that the lack of significant differences found based on fracture characteristics is due to limitations in power of the present study.

Conclusion: Our study demonstrates that although blood flow is significantly comprised following a FNF, some perfusion to the femoral head is maintained (possibly by the IRA and FA). A greater decrease in perfusion of the superior head is consistent with the presumed disruption of the SRA (a major contributor to the superior femoral head). The delayed washout noted in the injured side may signify an out-flow problem caused by either increased intraosseous/intra-articular pressure and/or disruption of the venous system. It therefore seems that compromise of femoral head vascularity during FNF is secondary to both an in-flow and outflow problem. Further validation of our findings with MRI studies after surgical fixation to assess for incidence, location, and size of regions of osteonecrosis within the femoral head and the potential effects on patient outcomes will be essential for establishing the value of this technique during preoperative evaluation of FNF.

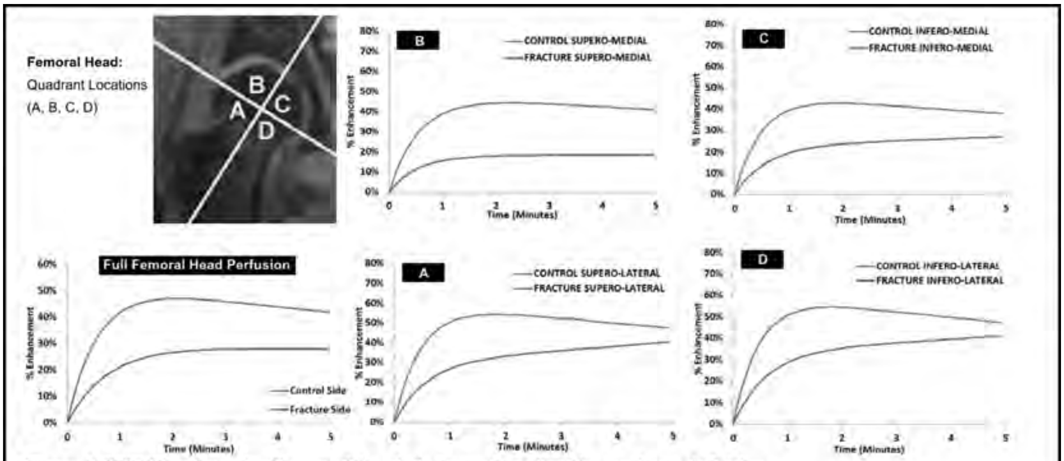

Figure 1. DCE Time Intensity Curves of the whole femoral head and by quadrants definition

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Table 1. Fracture Description

LOCATION		CORONAL DEFORMITY		PAUWEL'S ANGLE		TRANSLATION		POSTERIOR ROLL-OFF		MODIFIED AO CLASSIFICATION	
Subcapital	17	None	4	0-30°	3	None	18	<5°	10	Non-Displaced	10
Midcervical	12	Varus	7	30-50°	14	Proximal	12	>5°	21	Displaced	19
Basicervical	2	Valgus	20	>50°	14	Distal	1	<20°	19	Basal	0
								>20°	12		

Table 2. Garden Classification

Original Garden Classification	Type I 2	Type II 1	Type III 17	Type IV 11
Modified (1) Garden Classification	Non-Displaced: Non-Displaced AP 3		Displaced: Displaced AP 28	
Modified (2) Garden Classification	Non-Displaced: Type I & II with <5° Posterior Roll-Off 0		Displaced: Type I to IV with >5° Posterior Roll-Off 31	
Modified (3) Garden Classification	Non-Displaced: Type I & II with <20° Posterior Roll-Off 2		Displaced: Type I to IV with >20° Posterior Roll-Off 29	

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Vitamin D Deficiency in Orthopaedic Trauma

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Background/Purpose: Hypovitaminosis D is an insufficiency in the levels of vitamin D in the body. Vitamin D has an interrelationship with calcium homeostasis and bone metabolism, helping to maintain strong, healthy bones and muscles. Inadequate vitamin D levels can contribute to osteoporosis and subsequent vertebral body and skeletal fractures. Prevalence of this disorder has never been evaluated in orthopaedic fracture patients admitted at a Level I trauma center. The purpose of the present study was to measure the prevalence of hypovitaminosis D among orthopaedic surgery patients admitted at an academic Level I trauma center.

Methods: After IRB approval, a retrospective analysis was conducted on all patients admitted to the orthopaedic service at an academic Level I trauma center from September 1, 2009 through May 31, 2013. Patient medical records were used to obtain data, which included age, gender, and serum 25-hydroxyvitamin D level, if taken. It was noted whether the patients' 25-hydroxyvitamin D levels were normal (>32 ng/mL), insufficient (<32 ng/mL), or deficient (<20 ng/mL). The obtained levels were then categorized according to age and gender. The study included 315 patients, 30.5% of whom were males (n = 96) and 69.5% of whom were females (n = 219). The mean age for all patients was 54 years with the mean age for men at 49 years and the mean age for women at 61 years.

Results: In the present study, 84% of the fracture patients who had vitamin D levels measured were vitamin D insufficient ($P = 0.00$). Of these, we found that 84.4% of male fracture patients and 83.6% of female fracture patients were vitamin D insufficient, indicating that the prevalence of hypovitaminosis D in fracture patients is much higher than in the general population. Men were shown to have lower vitamin D levels than women with a mean 25-hydroxyvitamin D level of 21 ng/mL compared to 23 ng/mL, respectively ($P = 0.105$). The age group of 18 to 50 years of age was shown to have lower vitamin D levels than the older age groups (51 to 70 and older than 70 years of age) with the youngest age group showing 88.4% insufficiency and 58.1% deficiency. This correlation between younger age and lower vitamin D levels was statistically significant ($P = 0.019$).

Conclusion: The result that the youngest population yielded the lowest vitamin D levels is not consistent with former studies. However, this inconsistency could be due to the fact that awareness of the prevalence of hypovitaminosis D in the elderly has become known, and many physicians now prescribe vitamin D supplements to the older population to strengthen their aging bones. Hospitalization provides a unique opportunity for evaluation and treatment of this disorder, and levels of 25-hydroxyvitamin D should be measured in all patients admitted to a Level I trauma center. Hopefully, recognition that hypovitaminosis D is alarmingly high in fracture patients will raise awareness, and vitamin D levels will more readily be evaluated and treated.

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Does Malnutrition in Patients Presenting With Fractures Predict Lower Quality Measures?

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Purpose: The role of nutritional status in healing and successful postoperative recovery is well documented. We performed a retrospective review of clinical data over a 3-year period to determine if baseline malnutrition can also be used as a predictor for the development of complications and hospital readmissions.

Methods: A variation of the Malnutrition Universal Screening Tool (MUST) is administered at our institution as part of the in-patient nutrition screening process. In this system a nutrition score of greater than 0 identifies a patient at risk. We retrospectively collected available nutrition scores of patients treated between 2009 and 2011 for primary ICD-9 codes 808.0 through 838.3. Complication data for infection, deep venous thrombosis (DVT), pulmonary embolism (PE), and readmission were obtained from our quality and infection control departments. All data were compiled and analyzed using Excel, MATLAB, and SPSS.

Results: The distribution of nutrition screening scores in our total cohort (n = 786 patients) indicates that 61% were of normal nutritional status (Group A) and 39% exhibited at least one sign of malnutrition (Group B). In Group A (n = 477), 5.7% of the patients exhibited at least 1 complication and we observed a complication-to-patient ratio of 0.069. In Group B (n = 309), 12.0% of the patients exhibited at least 1 complication with a complication-to-patient ratio of 0.175. We found that patients in Group B were twice as likely to have a complication compared to patients in Group A ($P = 0.002$); this trend is consistent across each individual complication with varying significance levels (Table 1). In the multivariate regression analysis, both nutrition score and age were significantly associated with overall complication rates when adjusting for fracture site (upper vs lower extremity) and body mass index, with odds ratios of 1.71 (95% confidence interval [CI] 1.23, 2.39) and 1.05 (95% CI 1.03, 1.07), respectively.

Conclusion: The presence of malnutrition in patients who present to the hospital with fractures and require admission is not insignificant. We have observed that malnourished patients treated for fractures were nearly twice as likely to acquire some combination of infection, DVT, PE, or other reason for readmission than those of normal nutritional status. Furthermore, each additional point in a patient's nutrition score corresponded to a 71% increase in the odds of developing a complication. An assessment of a fracture patient's nutritional status should be considered a factor in evaluating risks related to fracture care. These data have important implications for hospitals whose fiscal reimbursement is dependent upon maintenance of defined quality measures.

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Table 1: Comparison of individual complication counts

Group	Infection	DVT/PE	Readmission
A: Nutrition Score = 0 (n = 477)	11	8	14
B: Nutrition Score >0 (n = 309)	20	22	12
P value	0.004*	<0.001*	0.541

*Statistically significant (*P* <0.05).

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Incidence and Risk Factors Associated With Deep Venous Thrombosis Among Hospital-Hospital Transfers with Pelvic and Lower Extremity Fractures

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Background/Purpose: This prospective study examined the incidence and potential risk factors for the development of deep venous thromboses (DVT) among orthopaedic trauma patients transferred from the inpatient unit of a community hospital (OSH) to two Level I trauma centers. These transfers were initiated due to the perceived complexity of care required by their admitting hospitals. The complexity of care was related to the orthopaedic injury, the patient's associated medical comorbidities, or both. The purpose of this study was to define an incidence of DVT among this population and identify associated risk factors.

Methods: All in-patient hospital-hospital transfers received by two Level I trauma centers found to have pelvic or lower extremity fractures were prospectively enrolled over a 2-year period from January 1, 2010 to December 31, 2012. Patients with a preexisting diagnosis of DVT or pulmonary embolism or receiving anticoagulation for other medical reasons at time of transfer were excluded from the study. Lower extremity noninvasive ultrasound was obtained to evaluate for the presence of DVT. Age, gender, mechanism of injury, and medical comorbidities were recorded for each transferred patient. Travel distance (miles), prophylactic anticoagulation at the outside facility, and length of stay (LOS) prior to transfer were recorded.

Results: 130 patients (64 women and 66 men) ranging from 19 to 101 years of age (median 74) were prospectively enrolled. 22 patients (17%) were found to have a DVT with 8% of patients (11 of 130) with DVT proximal to the knee. The median age was greater in patients diagnosed with DVT (80 years; range, 55-95) than patients without DVT (72 years; range, 19-101; $P = 0.04$). 42 patients (32%) received chemical anticoagulation at the OSH prior to transfer. Incidence of DVT did not differ between those who received pretransfer anticoagulation (17%, 7 of 42) and those who did not (17%, 15 of 88; $P = 0.96$). Median duration of admission at the OSH prior to transfer was the same between patients found with DVT (2 days; range, 1-12) and those without (2 days; range, 1-155; $P = 0.45$). Injuries in patients with DVT included 15 hip fractures, 4 distal femur fractures, 1 acetabular fractures, 1 femoral shaft fracture, 1 tibial plateau fracture, and 1 patient with both an acetabular fracture and proximal femur fracture.

Conclusion: Orthopaedic patients transferred to two Level I trauma centers had an overall DVT incidence of 17%, with 8% of patients having a DVT proximal to the knee. The incidence of DVT in orthopaedic patients with lower extremity trauma is estimated to be 5% in patients receiving low-molecular-weight heparin prophylaxis. Increased age was associated with a higher rate of DVT. Despite published guidelines, only 32% of transfer patients received chemical DVT prophylaxis prior to transfer. Prophylactic screening with duplex-ultrasound may be of value in the transfer patient population and can lead to the diagnosis and appropriate treatment of DVT prior to definitive surgical intervention.

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Gun Violence, Education, and the Orthopaedic Trauma Surgeon: A Model for Advocacy and Community Action

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Background/Purpose: Despite recent national attention, gun violence injuries remain highly prevalent in America's urban centers and disproportionately affect young people and minorities, often causing major musculoskeletal injury requiring orthopaedic surgical intervention. Furthermore, a previous study by the authors demonstrated, through a retrospective review of 343,866 emergency department visits at a busy Level I trauma center, that 40% of gunshot wound (GSW) patients were youth between the ages of 18 and 25, and that African-American patients are 3.3 times more likely to present with gunshot injuries as compared to their white counterparts. Multiple strategies have been employed to target the costly rise of gun violence across the nation, including school-based gun violence intervention programs, which have been shown to be very effective. In this study orthopaedic trauma surgeons together with educators piloted a violence prevention program in a local middle school, aiming to reach vulnerable young adults on the front end of gun violence.

Methods: The authors received a Robert Wood Johnson pilot project grant to develop a school-based intervention aimed at reducing youth gun violence. In total, 26 youth violence prevention strategies were reviewed nationwide, with a primary focus on universal, evidence-based, and classroom-centered prevention strategies. Interviews with founders of 19 active programs were conducted to identify the programs most suitable to schools' needs in preventing violence. Four programs were chosen, and their leaders reinterviewed. Additionally, two focus groups with young GSW patients were held to get firsthand accounts of youth gun violence in our community and what would constitute an effective and appropriate school-based intervention. Findings from the interviews and focus groups indicated that a peer-to-peer learning model would be an effective strategy for a violence prevention program. The authors ultimately selected the "Aggressors, Victims, Bystanders"(AVB) school violence prevention program, met with leading educators about implementing the program city-wide, and successfully piloted the AVB curriculum in a local middle school, using pre- and post-tests for evaluation.

Results: The "intervention group" comprised 71 students, who took identical 32-question tests before and after completing the AVB pilot course. Test questions used the Likert scale with gradients from "never" to "always" and from "completely disagree" to "completely agree," respectively. Comparing the aggregate scores of the pre- and post-tests, students showed improvement on 25 out of 32 total questions dealing with violence (78%), and improved on 6 out of 6 questions dealing specifically with gun violence (100%). On the post-test students demonstrated statistically significant improvements on 6 questions (P <0.05), 4 of which were in the section appraising "violent behavior." There was minimal pre-test bias (3 questions had significant positive bias, P <0.05) and minimal practice effect (3 questions had significant positive bias, P <0.05).

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Conclusion: This study shows how a targeted educational approach can change students' behaviors and views on gun violence. According to evaluative pre- and post-tests, students taking the AVB pilot course demonstrated clear and statistically significant differences in perceptions, attitudes, and behavior towards violence, especially gun violence. By implementing the AVB program, the authors provide an innovative model for community advocacy by orthopaedic trauma surgeons, who are uniquely positioned to examine the social context on the front end of injuries they treat, especially for youth GSWs.

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A PCR-Based Protocol for Testing for Methicillin-Resistant *Staphylococcus aureus* (MRSA) Colonization in Orthopaedic Trauma Patients: Final Analysis

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Purpose: Our objectives were (1) to determine the prevalence of MRSA colonization in orthopaedic trauma patients, (2) to identify risk factors for MRSA colonization, and (3) to implement the use of rapid polymerase chain reaction (PCR) amplification testing to determine MRSA colonization prevalence and guide perioperative antibiotic prophylaxis. We hypothesized that the prevalence of MRSA colonization is greater than that reported in the literature and that certain risk factors in the patients' history will predispose the patients to MRSA colonization. Furthermore, it was hypothesized that rapid PCR amplification has utility in orthopaedic trauma patients as it will help to quickly determine MRSA carriage status in order to tailor perioperative antibiotic prophylaxis appropriately.

Methods: The study population was all adult trauma patients who presented to a Level I trauma center with an orthopaedic injury that required surgical treatment. Upon admission, MRSA PCR amplification was performed using a nasal swab obtained in the emergency department. The main advantage of using rapid PCR over bacterial culture is that results are available much faster with PCR-based tests: providers can know a patient's MRSA carriage status within 4 hours with PCR compared to 2 days with bacterial culture. Patients who were MRSA carriers had their perioperative antibiotics changed to vancomycin to decrease the risk of infection with MRSA. Finally, charts were reviewed for basic demographic data, presence of chronic illness previously associated with MRSA colonization, recent hospitalizations, and past surgical history. Charts were also reviewed for social history also associated with MRSA, including obesity, drug use, and nursing facility residence. Univariate and multivariate analyses were then performed to identify the risk factors most associated with MRSA colonization.

Results: During the first 13 months of this ongoing study, 836 consecutive patients were admitted to the Level I trauma center with orthopaedic injuries that required surgical treatment. Of these, PCR identified 59 (7.1%) as being MRSA carriers. Due to positive MRSA test results, 43 patients (73%) had their perioperative antibiotics adjusted to vancomycin. Independent risk factors most strongly associated with MRSA colonization include previous MRSA infection (odds ratio [OR] 15.3, 95% confidence interval [CI] 6.2-37.7), chronic antibiotic use (OR 12.0, CI 5.1-28.3), obesity (OR 6.9, CI 3.1-15.2), chronic illness (OR 6.4, CI 3.6-11.1), recent hospital admissions (OR 5.5, CI 3.2-9.6), and gastrointestinal disease (OR 5.0, CI 2.8-8.5). On multivariate analysis, the most significant factors for MRSA colonization are: current infection (P <0.0001), gastrointestinal disease (P = 0.0001), and heart disease (P = 0.001).

Conclusion: We found the prevalence of MRSA carriage to be 7.1%, which is higher than previous figures in the orthopaedic literature and in our pilot data. Additionally, we have demonstrated that rapid PCR amplification for MRSA carriage has utility and can be insti-

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tuted in order to tailor perioperative antibiotic prophylaxis. Even after doing this for 1 year, there were still some instances of MRSA carriers not receiving vancomycin for perioperative prophylaxis. Adding MRSA status to the preoperative pause may be useful to assure proper administration of vancomycin.

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Lateral Fluoroscopic Projection Is Not Helpful in Judging Reduction of Tibial Plateau Fractures

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Purpose: This study was conducted to determine the utility of fluoroscopy in judging reduction of the tibial plateau articular surface.

Methods: Ten embalmed human tibial plateau cadaveric specimens (5 male and 5 female) with an average age of 65.7 years (range, 32-79) were selected. The extremities were fixed with an external fixator with two 5.0-mm half-pins in the femur and two in the tibia. The lateral tibial plateau of each specimen was sagittally sectioned into 7-mm slices using a band saw. The joint was reduced under direct visualization and held with a reduction clamp. Lateral, AP, and "joint line" (AP 10° cephalic to caudad) fluoroscopic views were obtained. One of the lateral plateau articular segments was displaced by 2 mm, and the bone was reclamped. The same fluoroscopic views were then obtained. This process was repeated with 5-mm displacement. Fluoroscopic images were placed into a 90-slide presentation in randomized order. One-third of the slides had only laterals, one-third featured an AP and lateral, and one-third featured the AP, lateral, and joint line view. Eight blinded, fellowship-trained orthopaedic traumatologists (years in practice ranged 7-15 years) were asked to grade whether the plateau was reduced (yes/no) on each slide. Within each pair of conditions (view and displacement), sensitivity, specificity, and interobserver reliability intraclass correlation coefficients (ICCs) were evaluated assuming random effects for both subjects and raters, where ICC of 0-0.2 was considered poor, 0.21-0.40 fair, and 0.41-0.60 moderate agreement.

Results: An AP-lateral view combination with 5-mm displacement yielded the highest accuracy for detecting reduction at 90% (95% confidence interval [CI]: 83-94%) followed by 2-mm displacement in this view (89% accuracy, 95% CI: 82-94%). Accuracy was 37% (95% CI: 26-50%) on the reduced lateral view. For the other conditions, accuracy ranged from 61%-83%. Odds of accuracy improved 5.2-fold (95% CI: 3.3-8.1) when using an AP-lateral view versus lateral alone (P <0.001), 2.8-fold (95% CI: 1.9-4.3) when using 3 views vs. lateral alone (P <0.001), 2.7-fold (95% CI: 1.8-4.1, P <0.001) at 2-mm step-off versus reduced and 3.0-fold (95% CI: 1.9-4.6, P <0.001) at 5-mm step-off versus reduced. Sensitivity was highest for the reduced lateral view (79%, 95% CI: 57-91%) and lowest for the reduced condition under 3 views (41%, 95% CI: 21-65%). Specificity was highest in the AP-lateral view at 97% (95% CI: 92-99%) for 2-mm step-off and 98% (95% CI: 93-99%) for 5-mm step-off. Interobserver reliability was perfect for the AP-lateral view with 5-mm displacement, but otherwise agreement ranged from poor to moderate (ICC = 0.09-0.46).

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Conclusion: This study demonstrates poor ability to assess reduction of tibial plateau fractures using a lateral view. The use of both AP and lateral views had the highest accuracy, specificity, and interrater agreement. This should raise clinically relevant concerns about the inability to interpret reduction fluoroscopically and may make a compelling argument for open or arthroscopic assessment of articular reduction.

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Δ A Biomechanical Study of Posteromedial Tibial Plateau Fracture Stability: Do They All Require Fixation?

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Purpose: The posteromedial fragment in tibial plateau fractures is largely considered unstable but no direct biomechanical evidence exists. Our hypothesis was that despite combined effects of loading conditions, there would be some size posteromedial fracture fragment that could maintain stability throughout a range of knee motion thereby allowing for nonsurgical intervention.

Methods: Loads were applied to the femurs of 5 fresh cadaveric knees and Tekscan pressure mapping systems were used to measure pressure, contact area, and force applied between the femoral condyles, meniscus, and tibial plateau. A Microscribe 3D digitizer (Immersion Corp) was used to define the positions of the femur and tibia in 3-dimensional space. A 10-mm fracture line was created with a saw with respect to the posterior tibial plateau (PTP) at an angle of 30° and 75° in the sagittal plane. At each flexion angle and each loading condition (98 N compression with 50 N posterior shear, 98 N compression with 2 Nm internal torque, 98 N compression with a 98-N induced varus on the medial tibial plateau), femur subluxation and fracture fragment displacement were determined and displayed.

Results: For the 10-mm fragment, the displacement was little affected up to approximately 30° flexion, after which the displacement increased. For the 20-mm fragment, there was progressive displacement with increasing flexion up to at least 10°. The average distal subluxation of the 20-mm fragment was 2.9 mm during compression only, and increased to 3.9 mm with the varus moment.

Conclusion: In this cadaveric model of a posteromedial tibial plateau fracture, both the 10-mm and the 20-mm fracture fragment displaced significantly with knee flexion. While this fragment may initially appear nondisplaced after injury, these fragments are likely to displace during range of motion if this fragment is not specifically addressed surgically.

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Δ OTA Grant

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Changing Presentation of Knee Dislocation With Vascular Injury in the Obese

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Purpose: Reports in the surgical literature of low-energy (LE) knee dislocations (KDs) in obese patients are increasing. Little is known about the rates of KD by LE mechanisms and the outcomes of these patients compared to those with high-energy (HE) dislocation.

Methods: All KDs presenting to the emergency department of a large urban Level I trauma center were reviewed. Patient demographics, body mass index (BMI), injury mechanism, associated nerve and vascular injuries, time to angiography, rates of external fixation and ligamentous reconstruction, direction of dislocation, Schenck classification, and phone-administered Short Form-36 scores were recorded and compared between HE dislocations (defined as motor vehicle accidents and crush injuries) and LE dislocations (defined as low-energy falls or sports injuries).

Results: Between January 1995 and April 2012, there were 53 patients with KD; 28 (52.8%) had HE injuries and 25 had LE injuries with 18 (34.0%) in the latter group classified as obese (BMI >30).

Characteristic	High-Energy (n = 28)	Low-Energy (BMI< 30) (n = 7)	Low-Energy (BMI >30) (n = 18)	Low-Energy (BMI >40) (n = 13)
Isolated extremity injury	12 (42.9%)	5 (71.4%)	18 (100%)	13 (100%)
Any vascular injury	3 (10.7%)	0 (0%)	6 (33.3%)	5 (38.5%)
Popliteal repair	2 (7.1%)	0 (0%)	5 (27.8%)	5 (38.5%)
Nerve injury	2 (7.1%)	1 (14.3%)	9 (50.0%)	7 (53.9%)
Length of stay (days)	11.4 ± 15.9	3.7 ± 3.0	8.1 ± 9.3	9.2 ± 10.8

LE KDs in obese patients were associated with increased rates of nerve injuries and open popliteal artery repair compared to both HE KD patients and nonobese LE KD patients (P <0.001 and P <0.038 respectively). The rates of arterial and nerve injuries were greatest in the most obese (BMI >40) (P = 0.01 and P <0.001, respectively). Despite lower NISS (new injury severity score) and having isolated trauma (P = 0.002), obese patients with LE KD stayed in hospital just as long as multisystem trauma, HE KD patients. Between 1995 and 2012, LE KD in the obese represented an increasing proportion and eventual majority of all KDs at our institution (P = 0.02).

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Conclusion: LE KDs in obese patients are increasingly common and present unique challenges. These patients are more likely to have vascular and nerve injuries and are more likely to require open vascular repair than patients with HE trauma or nonobese patients with LE KD.

See pages 91 - 132 for financial disclosure information.

Tibial Plateau Fractures and Compartment Syndrome:
When Should ORIF Be Performed?

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Background/Purpose: Tibial plateau fractures with ipsilateral compartment syndrome are a clinical challenge the ideal time for operative fixation to reduce the risk of surgical site infection is unknown. The primary purpose of this study is to evaluate if infection rates are related to the timing of open reduction and internal fixation (ORIF) of the fracture relative to the closure of the fasciotomy wounds.

Methods: A retrospective review was conducted at an urban Level I trauma center to identify patients from 2003 to 2011 with tibial plateau fractures (n = 716) and an ipsilateral compartment syndrome (n =71, 10% of fractures). All patients were diagnosed by an attending orthopaedic physician and treated with emergent four-compartment fasciotomy. The primary outcome measure was deep surgical site infection after ORIF. The results in the compartment syndrome patients were further stratified into 3 treatment groups: (1) ORIF <u>before</u> fasciotomy closure, (2) ORIF <u>at the same time</u> as fasciotomy closure, or (3) ORIF <u>after</u> fasciotomy closure. Fasciotomy closure involved either secondary closure or skin grafting. Our results were also combined with previous published data. Fisher exact test and χ^2 analyses were used with a *P* value of 0.05 as significant.

Results: Eighteen (25.4%) of the fractures in the fasciotomy group subsequently became infected, which is significantly greater than the rate in the control group (7.7%, P <0.0001). There was, however, no statistically significant difference (P = 0.87) found in the infection rates based on timing of definitive fixation relative to fasciotomy closure (before: 31%, n = 16; at the same time: 21%, n = 14; or after: 24%, n = 41). These results held true when data from previous studies were combined to show no significant difference based on timing of fixation (n = 171, P = 0.53).

Conclusion: Our data demonstrated that tibial plateau fractures with an ipsilateral compartment syndrome have an approximately three-fold increased risk of infection as compared to those without compartment syndrome (P <0.0001). Our data support previous authors who have demonstrated higher rates of infection and may indicate that clinicians should be alerted to increased risk of surgical site infection in these patients. Regardless, there is still no clear evidence supporting a particular time for fixation of tibial plateau fractures relative to fasciotomy wound coverage.

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Aquatic Weight Bearing for Periarticular Fractures Improves Function in the Near Term

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Purpose: The purpose of this prospective study is to evaluate the effect of a standardized physical therapy protocol for early weight bearing in water on the clinical outcomes of patients with lower extremity articular fractures. Our null hypothesis is that the early weight-bearing protocol will have the same effect as a traditional 10-week non–weight-bearing protocol on clinical outcomes.

Methods: Patients greater than 18 years of age being treated for a lower extremity articular (acetabular, tibial plateau, or tibial plafond) fracture were asked to participate in this prospective cohort study. Patients were excluded if they had wound complications deemed unsafe for immersion, multiple articular injuries, or inability to access a pool for therapy. The control cohort of the study consisted of patients treated with 10 weeks of a standard postoperative non–weight-bearing protocol. The study cohort consisted of patients undergoing an immersion therapy protocol. Postoperatively both groups of patients remained non–weight bearing and range of motion therapy was initiated while in the hospital. Patients began immersion therapy at 4 weeks postoperatively. For the first 2 weeks of immersion therapy, patients performed their physical therapy immersed in the pool to their neck (5%-10% total body weight). After this, during weeks 6 through 8, patients were immersed to their midchest (15%-30% total body weight). During weeks 8 to 10, patients were progressed to physical therapy while immersed only to their waist (navel level; 50%-60% total body weight). At 10 weeks, patients were allowed to bear weight as tolerated and began formal dry land ambulation. The Short Musculoskeletal Function Assessment (SMFA) was administered at patients' 3-, 6-, and 12-month visits. Standard postoperative radiographs were obtained and assessed for loss of fixation. Secondary outcomes were postoperative infections and secondary surgeries.

Results: The control and study cohorts consisted of 27 and 25 patients, respectively. Patient age (45.6 years; range, 25-71) and fracture distribution were similar between groups. There were three postoperative infections in the control cohort and two infections in the study cohort ($P = 1.0$). Ten study group patients and 11 control group patients underwent secondary surgeries ($P = 1.0$). No patient in either group experienced loss of fixation. Patients in both groups experienced significant improvement in all domains of SMFA from 3 months to 12 months. Patients in the immersion therapy group had significantly less dysfunction ($P = 0.041$), daily activities ($P = 0.047$), and bothersome ($P = 0.026$) scores compared to the control patients at 3 months. There were no significant differences in any of the SMFA domains between the study and control groups at 6 and 12 months.

Conclusion: There is no difference in number of complications or secondary surgeries between patients that undergo an immersion therapy protocol as compared to the traditional non–weight-bearing postoperative protocol. Early immersion therapy may provide improvement in patient outcome at 3 months, but this improvement is not detectable at 6 and 12 months.

See pages 91 - 132 for financial disclosure information.

A Prospective Study of Pain Reduction and Long-Term Knee Dysfunction Comparing Femoral Skeletal Traction and Splinting in Adult Trauma Patients

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Purpose: Distal femoral traction pins are commonly used for provisional stabilization of femoral shaft, acetabular, and unstable pelvic fractures. The effects of traction pins on the knee are unknown. The purposes of this study were to determine if distal femoral traction pins result in long-term knee dysfunction and if traction relieves pain more effectively than splinting for femoral shaft fractures.

Methods: 108 adult patients with femoral shaft, acetabular, and unstable pelvic fractures were enrolled at the time of injury in a prospective cohort study. 70 patients (65%) completed 6-month follow-up (f/u) and comprised the study group. There were 50 male and 20 female patients with a mean age of 42.5 years. Mean f/u time was 10.8 months. 38 patients (54%) had femoral fractures, and 32 (46%) had acetabular/unstable pelvic fractures. Patients with femoral shaft fractures were placed into distal femoral skeletal traction or into a long leg splint, based on an attending-specific protocol. Similarly, patients with pelvic or acetabular fractures who had instability or intra-articular bone fragments were placed into skeletal traction and those without were treated without traction or immobilization. An initial Lysholm knee survey (100-point scale) was administered to assess preinjury knee pain and function. Also, a 10-point visual analog pain scale was used to document pain immediately before, during, and immediately after fracture stabilization. F/u Lysholm surveys as well as radiographs were obtained at 6-month follow-up visits, and patients who did not return were called to obtain their 6-month Lysholm score.

Results: 52 patients were treated with skeletal traction and 18 had a long leg splint applied. All patients except one underwent subsequent surgical fixation. Mean Lysholm knee scores at 6-month f/u were reduced for both traction (–9.9%, $P = 0.0004$) and splint (10.8%, $P = 0.13$) patients compared to baseline. There was no significant difference in Lysholm score change between the traction and splint patients ($P = 0.91$). In comparing mean change in Lysholm score between femoral shaft and acetabular/pelvic fracture patients treated with traction pins, there was again no significant difference ($P = 0.94$). Mean immediate poststabilization pain score reduction was not significantly different between patients placed into traction and those who were splinted for femoral shaft fractures ($P = 0.29$). However, the mean pain level during skeletal traction placement was significantly less than the pain level during splint application (score of 6.8 for traction vs 8.3 for splints, $P = 0.02$).

Conclusion: Patients immobilized with skeletal traction as well as those placed into splints reported worsened knee function at 6 months; neither technique was statistically superior for reducing postinjury knee disability. The lack of significant difference in Lysholm scores between femoral shaft and acetabular/pelvic patients placed in traction suggested that fracture type and the presence of distal interlock screws were not confounding variables. Skeletal traction patients reported less pain during application than those who had a splint

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applied; however, there was no difference in reported pain after stabilization between groups. In conclusion, distal femoral skeletal traction to stabilize femoral shaft, acetabular, and unstable pelvic fractures does not appear to place patients at greater risk for additional long-term knee morbidity than does splinting.

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Δ Time-Dependent Contamination of Open Irrigation Fluid in Orthopaedic Surgery

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Purpose: The purposes of this study were to evaluate the contamination rate of operative irrigation fluid over time, to determine the pathogens causing bacterial contamination, and to evaluate the efficacy of a simple intervention (covering the irrigation basin with a sterile towel) on decreasing contamination rates. Our hypotheses were that contamination rates would increase over time and that coverage of the irrigation fluid with a sterile towel would decrease the contamination rate.

Methods: The study was performed in 38 closed orthopaedic trauma and spine cases in which the patients had no known source of infection. Cases were at least 4 hours in duration and included spine, acetabular and pelvic trauma, and complex extremity trauma. Three sterile basins were opened at the beginning of each case and filled with 1 L of sterile saline. The control basin was left uncovered, outside the sterile field. A second basin (towel) was placed adjacent to the control basin and covered with a sterile surgical towel immediately after opening. A third basin (scrub) was placed uncovered within the operative field and was allowed to be handled by the scrub technician, although the fluid in this basin was not used in the case. At baseline and for each hour, 200 mL of irrigation was collected in a sterile pipette. 10 mL of each sample was placed into a 50-mL container, and the remaining 190 mL was filtered through a 0.22-μm filter. The filter was placed into a 50-mL sterile container with the 10-mL aliquot and vortexed for 30 seconds. Two aliquots of the 10-mL solution were swabbed onto a blood agar plate and incubated in ambient air at 36°C for 48 hours. The organism type was determined using our microbiology laboratory standard techniques for culturing and identifying organisms.

Results: Basins that were covered with a sterile towel demonstrated a statistically significant lower contamination rate at 4 hours compared to uncovered basins (19.8% vs 48.3% control and 59.2% scrub). The control and scrub basins demonstrated a linear increase in the contamination rate over time, while the towel-covered basin did not. Rates of contamination at 0, 1, 2, 3, and 4 hours for each group were: control 15.1%, 23.5%, 46.9%, 48.3%; scrub 6%, 26.7%, 33.3%, 38.7%, 59.2%; and towel 3%, 9.1%, 20.5%, 18.8%, 19.5%. The most common bacterial identified was *Staphylococcus epidermidis* (35.7%) followed by gram-positive rods (29.2%), *Ralstonia pickettii* (12.9%), and micrococcus (9.0%).

Conclusion: Placing a sterile towel over opened irrigation solution or opening the irrigation when needed can reduce levels of contamination and thus the risk of surgical site infection and orthopaedic implant infection.

Δ OTA Grant

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Fact or Fiction for Penetrating Trauma: Is Follow-up Worse?

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Background/Purpose: Patients are frequently excluded from prospective research studies if their injuries are due to penetrating trauma even if they might otherwise meet inclusion criteria due to concern that they are unlikely to make follow-up after they leave the hospital. Is this myth or fact? We sought to either validate or disprove this selection bias by retrospectively evaluating orthopaedic trauma patients after a long bone fracture due to either penetrating or blunt trauma.

Methods: The trauma database of a Level I trauma center in a major metropolitan area was used to compile all patients with long bone fractures from penetrating trauma from January 2006 to June 2009 (n = 132). This same database was used to demographically match blunt trauma patients with long bone fractures by gender, race, and age (n = 104). A retrospective chart review was conducted to obtain patient follow-up at 3, 6, 9, and 12 months from the time of injury in patients with long bone fractures from blunt or penetrating trauma. Patients scheduled to return on an as-needed basis were considered to have complete follow-up. Secondary outcome measurements included gender, race, age, surgical fixation, and history of tobacco, alcohol, or drug use.

Results: There was no statistically significant difference ($P = 0.736$) between the penetrating and blunt trauma patients in terms of their follow-up within 1 year from time of injury. At the 1-year end point 103 of 132 patients (78.03%) in the penetrating group and 83 of 104 (79.81%) in the blunt group were lost to follow-up. There was no statistically significant difference with follow-up with regard to gender ($P = 0.1217$), race ($P = 0.9602$), age ($P = 0.3732$), or tobacco use ($P = 0.129$). There was borderline significance with alcohol use ($P = 0.061$) with a slightly higher prevalence in the penetrating group (62.12% vs 50%). There was a statistically significant difference with drug use ($P = 0.017$) with a higher prevalence in the penetrating group (30.3% vs 17.31%). There was also a statistically significant difference with surgical fixation ($P = 0.003$) with a higher rate of surgery in the blunt group (89.42% vs 75%). A power analysis that was conducted demonstrated a power of >90% in detecting <20% difference in follow-up between the penetrating and blunt patients based on our sample size.

Conclusion: Despite a statistically significant higher prevalence of drug use and nonoperative management in the penetrating trauma group, there was no statistically significant difference in the rate of follow-up within 1 year from time of injury compared to the blunt trauma group. Potential confounding variables such as gender, race, age, tobacco use, and alcohol use were found to have no statistically significant difference between the two groups. This calls into question the commonly accepted theory that patients with penetrating injuries are less likely to follow up, at least in an academic Level I trauma center population.

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Fracture Pain Management in the Emergency Room: Is There a Bias?

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Background/Purpose: Pain control is an integral part of long bone fracture management. It is the role of orthopaedists, emergency room physicians, and nurses to appropriately manage pain in the acute presentation of long bone and pelvic fractures. Previous studies have identified race, gender, and age to be risk factors associated with poor pain management in the emergency room. The purpose of this study was to determine whether patients with long bone and pelvis fractures had their pain adequately controlled during their presentation at an urban Level I trauma center emergency room.

Methods: A retrospective cohort study design was used to evaluate pain management in emergency room patients with long bone and pelvic fractures. Measurements retrieved from electronic medical records include time to administration of pain medication and verbal rating scale (VRS) before and after analgesic was given. Basic demographic information and fracture type were also collected. The primary outcome measure was pain management index (PMI), a calculation using initial pain severity and choice of analgesic medication used (whether narcotic or not).

Results: The study sample included 300 participants from three racial groups: 100 whites, 100 blacks, and 100 Hispanics. The mean time to presentation for the study sample was 0.97 days with no significant difference between subgroups. Likewise, the overall mean verbal rating score was 7.1 (range, 0-10) on arrival and 4.6 (range, 1-10) on departure from the emergency room, again with no significant difference found between subgroups. PMI revealed that the majority of patients did not receive adequate pain management. A higher percentage of whites received adequate pain management (53%), while only 37% of blacks and 39% of Hispanics had their pain adequately managed ($P < 0.05$). Interestingly, after accounting for race, age was inversely proportional to adequate pain management ($P = 0.01$).

Conclusion: Pain management in patients with long bone and pelvic fractures continues to be an issue in the emergency room setting. Race and age continue to play a role in management of pain and treating personnel must be trained in adequate pain recognition, control, and cultural awareness.

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Can Fracture Surgical Skills Courses Improve Resident Performance?

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Purpose: Fracture surgical skills courses have been offered as orthopaedic surgery resident education adjuncts for more than 40 years. We hypothesized that resident participation in a hands-on principles of fracture fixation course would lead to significant improvement in performance assessed in a simulated fracture fixation model.

Methods: 23 second-year orthopaedic surgery residents participated in a Sawbones fracture fixation simulation at two different time points, with each resident tasked to treat a short oblique fracture of a radial shaft using standard fixation techniques. At the time of the initial simulation, 6 of the residents had participated in a surgical skills course focused on the principles of fracture fixation, while the remaining 17 had yet to attend the course. The simulation was then repeated 6 months later at which time each resident had attended the surgical skills course. A board-certified orthopaedic traumatologist familiar with the skills course curriculum directly assessed resident performance during the simulated fracture fixation. The assessment included an evaluation of each step of the procedure (done correctly, partially done, or not done) in addition to an overall score based on a modification of the Objective Structured Assessment of Technical Skill (OSATS) scoring system. Comparisons were made between the two resident cohorts and between the two testing time points.

Results: There was a significant improvement in the percentage of tasks completed correctly (71.7% vs 89.4%) and in the OSATS score (15.4 vs 18.3) for the overall resident cohort between the two testing time points (P <0.0001 and P <0.03, respectively). Residents who had not participated in the surgical skills course demonstrated significant improvements in the percentage of tasks completed correctly (58.5% vs 88.5%) and OSATS score (12.9 vs 17.0) following course completion (P <0.0001 and P <0.007, respectively). No significant difference was noted in performance for the cohort of residents who had already participated in the surgical skills course (P = 0.87 and P = 0.68). Comparison between the residents who had previously completed the course and those who had not showed significant differences in the percentage of tasks completed correctly (90.2% vs 58.5%) and in the OSATS score (19.0 vs 12.9) at the time of initial evaluation. At the time of the second simulation no significant difference was seen with respect to task completion but a significant difference still existed in OSATS score (20.0 vs 17.0; P <0.03).

Conclusion: Participation in a formal surgical skills course led to significantly improved practical operative skills as assessed in a standardized simulated fracture fixation model. The benefits of the course were maintained out to 6 months, with residents who completed the training earlier continuing to demonstrate an advantage in surgical skills. Orthopaedic surgery skills courses are a valuable academic and training resource that directly impacts resident performance.

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Treating the Trauma Knowledge Gap: A Validated Approach to Understanding Resident Knowledge and Addressing Deficiencies

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Background/Purpose: Current adult education principles suggest that the ideal method for developing a course curriculum is through backwards planning. Learner needs are best understood by determining a knowledge gap (the difference between what is thought to be known and what actually is known) Despite the existence of trauma courses, little is known regarding the baseline knowledge levels of orthopaedic residents and how this can be impacted by participation in a structured basic fracture course. The purpose of this study is to define the trauma knowledge gap in junior residents and to determine if this gap can be addressed through a structured trauma curriculum.

Methods: 355 residents participating in 3 national trauma courses using a standardized curriculum were prospectively given a 20-item test of basic fracture knowledge before and after participation in the course as part of a quality initiative. The test items were designed to test 15 distinct areas of knowledge and were formatted in keeping with the Royal College of Physicians and Surgeons of Canada standards for multiple-choice question design. All questions were validated for content through testing of fellowship-trained trauma faculty in previous courses. Knowledge deficits were defined as questions which received <75% correct responses prior to course participation. McNemar's test was used to compare pre- and post-testing correct response rates with significance set at P <0.05.

Results: The baseline knowledge averaged 63% on the pre-test and 81% on the post-test (P <0.001). The pre-test response score was less than 75% for 15 of 20 items, indicating a significant knowledge gap. 80% of the questions had a statistically significant increase in score from pre-test to post-test (P <0.0001 to 0.02), indicating that the course changed the score for these items. There was no change in score for a control question (subject not covered at this course, P = 0.79) or for two questions where the baseline knowledge was high (eg, 99%) on the pre-test.

Conclusion: Junior residents appear to have a relatively low baseline knowledge level upon entrance into a basic fracture course, suggesting that supplemental fracture courses may play an important role in resident education. Details of the knowledge gaps allow for course planning through a validated needs assessment as well as changes in curriculum for topics that do not improve during the course or are already known on entrance to the course. Further, this particular format showed significant improvement in resident knowl-

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edge, indicating that in the short term resident knowledge is impacted significantly by the course. Further studies await investigation if this effect is long-lasting and what educational techniques optimize this benefit.

Clinical and Economic Impact of Duplicated Radiographic Studies in Trauma Patients Transferred to a Regional Trauma Center

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Background/Purpose: In today's climate of cost containment, financial resources are limited. The duplication of radiographic studies creates significant unnecessary health-care expenditures. Previous studies have indicated that at least 30% of Americans live more than 30 miles from a regional trauma center. In our home state of Nevada the distances are much larger as we cover a population of 800,000 living in an area in excess of 80,000 square miles. Many trauma patients are evaluated at rural emergency rooms and transferred to our institution. Upon transfer, radiographic studies are often repeated. Our purpose is to identify the reasons for duplicate studies, the costs associated with this practice, and the clinical effect on patients.

Methods: Our institutional database was queried to identify patients with orthopaedic injuries transferred to our regional trauma center from outlying hospitals. Duplicated CT scans, radiographs, and other studies were recorded. The radiation exposure was estimated based on study type and average values. The cost of duplicated studies, including technical and physician reading components, was provided by the hospital financial department.

Results: From January 1 to December 31, 2012, 513 trauma patients were accepted in transfer from 36 hospitals, clinics and urgent care facilities. 245 patients had repeated studies. There were 290 repeat CT scans (47.8%) and 161 (31.7%) repeat radiographs. The average patient with a duplicated CT scan received an additional radiation dose of 7.78 mSV. The average patient requiring duplicated radiographs received an additional 0.05 mSV. Total mean radiographic dose was 38.01 mSV per patient. 4.08% of patients received doses in excess of the 50-mSV threshold for increased cancer risk. Reasons for duplication included inadequate data transfer, poor study quality, inappropriate CT sequence, incomplete x-ray views, and physician preference. Based on our hospital Medicare fee schedule for duplicated studies, the additional cost is estimated to be $94,000. Assuming that this is a nationwide phenomenon and 2.6 million trauma admissions occur each year in the United States, duplicated studies result in $476 million in annual costs.

Conclusion: The problem of radiographic duplication is significant from both a clinical and economic standpoint. However, unlike many problems in health care, it has several solutions. ATLS (Advanced Trauma Life Support) guidelines are very clear on which patients requiring transfer need CT scans. Enforcing these guidelines is essential. Improving data transfer should be a primary objective, as potential cost savings are massive. The legal implications of additional radiographic exposure linked to carcinogenic potential cannot be ignored. Statewide physician education, oversight, and attention to this cost center are imperative.

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The Intraoperative Interobserver Reliability of the Orthopaedic Trauma Association Open Fracture Classification Versus the Gustilo-Anderson Classification

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Background/Purpose: The most widely used classification for open fractures is the Gustilo-Anderson classification, which has moderate to good reliability but has multiple shortcomings. For example, it was originally designed only to predict infection risk in open tibia fractures and it incorporates concepts of treatment such as method of soft-tissue coverage that may evolve over time. In 2010 the OTA developed a new comprehensive method for rating open fractures using 5 categories—Skin, Muscle, Arterial, Contamination, and Bone Loss, each with 3 levels of severity—which utilizes only injury characteristics. We evaluated the interobserver reliability of the OTA classification and compared it to the classic Gustilo-Anderson system.

Methods: From September 1, 2012 to January 31, 2013, 38 consecutive open fractures involving all extremities including phalanges were evaluated intraoperatively. The two most senior surgeons involved in the initial débridement (attendings, fellows, or chief residents) independently rated the fracture using both the OTA and Gustilo-Anderson classifications using a standardized form. Interobserver reliability was assessed using the weighted kappa statistic. A kappa-value of 0.41 to 0.60 was considered moderate, 0.61 to 0.80 was considered good, and ≥0.81 was considered excellent.

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Results: Seven upper extremity fractures and 31 lower extremity fractures were rated. The OTA subcategories of Skin and Arterial showed excellent correlation, and the category for Muscle had good correlation between raters. The categories for Contamination and Bone Loss had moderate interrater correlation. Only one fracture in the Contamination subcategory deviated by more than one level of severity. In comparison, the Gustilo-Anderson rating showed good interrater reliability and had one fracture that deviated by more than one level of severity.

	OTA					Gustilo-Anderson
	Skin	Muscle	Arterial	Contamination	Bone Loss	
Weighted Kappa	1.00	0.76	0.85	0.53	0.52	0.73

Conclusion: This is the first study to report on the interobserver reliability of the 2010 OTA classification for open fractures and is unique in its use of intraoperative assessment and a real-life clinical situation rather than recorded media. Elements of the OTA classification have better interrater agreement than the Gustilo-Anderson system and avoid the use of treatment method in the assessment. The subcategories of Contamination and Bone Loss may require additional education and clarification.

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Drilling Technique Can Minimize Plunging

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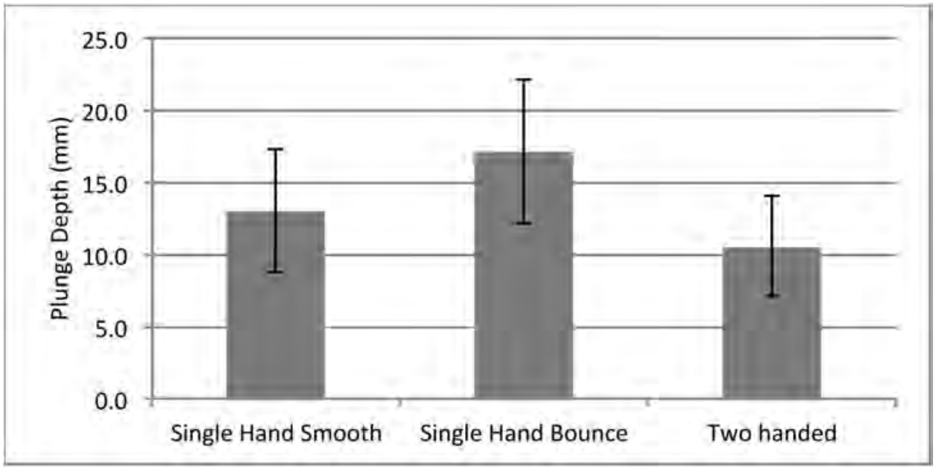
Purpose: Vibratory and acoustic feedback, drill sharpness, and material density have each been shown to influence the depth of plunging when drilling through bicortical bone. We hypothesized that drilling technique can also influence the depth of plunging.

Methods: Six subjects of various levels of training (postgraduate year [PGY]1 to 16-year-experienced surgeon) were asked to drill through a cortical bone surrogate, third-generation Sawbones tube with similar density and compressive modulus of healthy cortical bone. Using a sharp 4.5-mm drill and System Six drill, each participant drilled 30 holes wearing surgical gloves (mimicking tactile feedback) and using three different techniques (10 holes each). The techniques were: single handed smooth drilling, single-handed bounce technique, and two-handed smooth drilling. A 60-frame/sec high-definition video recorder was placed a standard distance from the model and used to calculate the depth of plunging. Analysis of variance with Fisher's PLSD post hoc was used to compare techniques (significance P <0.05).

Results: The average ± standard deviation plunge depths were: 13.0 ± 4.2 mm (range, 6.2-26.8 mm) for single-handed smooth, 17.2 ± 5.0 mm (range, 8.0-28.8 mm) for single-handed bounce, and 10.6 ± 3.5 mm (range, 5.8-19.2) for two-handed smooth techniques. All three techniques were significantly different.

Conclusion: Bounce technique had the greatest average depth and variance. The two-handed technique demonstrated the least plunge and the lowest variance, indicating the highest degree of control. Average plunge depth was slightly higher than previous studies that used smaller drill bits. This study supports the use of a double-handed technique for drilling when intraoperative circumstances permit.



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•A Randomized, Double-Blind Pilot Study of Pregabalin as an Adjunct for Postoperative Pain Management in Orthopaedic Trauma Patients

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Purpose: Our objective was to determine the effectiveness of pregabalin as an adjunct to the management of postoperative pain in patients with orthopaedic trauma.

Methods: A randomized, double-blind study was conducted comparing fracture patients treated with pregabalin 75 mg (Group A), pregabalin 150 mg (Group B), or placebo (Group C) administered as a scheduled twice-daily dose. Postoperatively, subjects were administered study drug and placed on a standard patient-controlled anesthesia (PCA) protocol. When they discontinued PCA therapy, they were offered hydrocodone or oxycodone in addition to the scheduled study drug. If the standard postoperative opioid protocol was insufficient to control pain, fentanyl or hydromorphone were available as rescue drugs. The total opioid volume administered during hospitalization was converted to Morphine-Equivalent Daily Dose (MEDD).

Results: 81 patients enrolled in the study, with 27 in each group. All patients underwent a single orthopaedic surgery for an isolated fracture. There were 57 male and 24 female patients with a mean age of 39.5 years. Four patients withdrew from the study (two from Group A, two from Group B) due to side effects from pregabalin. Nine patients (36%) from Group A, five (20%) from Group B, and nine (33%) from Group C used rescue medication ($P = 0.285$) during hospitalization due to inadequate pain control. The mean MEDD used per day, per patient is shown in the table below:

	Group A*	Group B*	Group C
MEDD (standard deviation)	19.7 (8.1)	24.2 (9.2)	27.6 (19.0)
95% confidence interval	16.3-23.2	20.6-27.9	19.9-35.3
	$P = 0.07$	$P = 0.41$	

*Compared to placebo.

There were no significant differences in visual analog scale scores for pain at rest, pain with activity, worst pain, and pain with physical therapy between low-dose pregabalin and placebo groups, but the high-dose pregabalin group reported significantly higher pain at rest scores ($P = 0.03$) and pain with activity ($P = 0.01$) than placebo.

Conclusion: Patients who use low-dose pregabalin after surgery for fractures demonstrated a trend towards lower opioid requirements during hospitalization. Administration of low-dose pregabalin reduced opioid use by 40%. Post hoc power analysis suggests that a study with 54 patients in each group would be required to determine the clinical significance of pregabalin use for pain control in postoperative fracture patients.

See pages 91 - 132 for financial disclosure information.

Professional Demands and Stress in Orthopaedic Trauma: An Orthopaedic Trauma Association Member Survey

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Background/Purpose: Orthopaedic trauma has long been regarded as a rewarding subspecialty; however, it has also been described as demanding and challenging for surgeons with regard to managing stress, family, and career satisfaction. A small number of studies had examined the professional demands in orthopaedics with a focus on residents, faculty, and department leaders. The literature does not have any studies focused on the professional demands and stress management strategies geared toward the orthopaedic traumatologist. We present data from a survey of 263 OTA members evaluating the professional demands that exist for an orthopaedic trauma surgeon as well as the strategies employed for stress management. We hypothesize that stress level would be related to factors including call nights, practice structure, weekly work hours, and commute.

Methods: After approval by the OTA research committee, all U.S. members of the OTA were e-mailed a link to a 30-question survey. This survey was open to members through the link and the OTA website from July through November of 2012. The survey was designed to capture information in 5 critical areas: training/experience, practice characteristics, demands, stress management strategies, and satisfaction.

Results: Overall, 263 members replied to the survey. Most respondents were fellowship-trained (218, 82.9%) and had a trauma-based practice (224, 85.2%). Respondents were predominantly young (<5 years in practice, 34.4%) or established surgeons (>15 years, 28.5%). Surgeons worked between 65 and 80 hours/week (123, 46.8%) and took call 5 to 7 nights a month (113, 43%). Practice type was largely academic (122, 46.4%) with >7 partners (130, 49.4%), and with mid-level support (242, 92%). Most surgeons are currently married (229, 87.1%) and have not been divorced (226, 85.9%). Most surgeons rated their stress level as high, but manageable (110, 41.8%) while a significant minority reported that the stress level either affects their performance or has led to a job change (30, 11.4%). Respondents managed their stress via a combination of exercise (184, 70.0%), drink after work (73, 27.8%), or nothing (46, 17.5%). The majority of respondents have felt some financial stress (143, 54.4%). Most respondents felt their job stress affects their personal life (178, 67.7%). Some respondents use medications or alcohol to reduce their stress (74, 28.1%). Most respondents had children (215, 81.7%) and 28.8% of those with children felt that their career did not allow them to be as involved in their children's lives (62, 28.8%). Nearly all surgeons would choose orthopaedic trauma as a career again (239, 90.9%); however, 40.7% (107) would not recommend medicine to a family member or friend.

Conclusion: This study illustrates the challenges of a career in orthopaedic trauma. While the majority of surgeons are satisfied with their job and manage stress accordingly, a significant number of trauma surgeons expressed stress levels that affect their work, finances, and

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personal life. Through our continued analysis, we hope to provide a better understanding of the personal, political, and development issues that may

Does Radiation Exposure Affect Vision and Eye Health?

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Background/Purpose: Intraoperative fluoroscopy is an important tool in the armamentarium of the orthopaedic surgeon. Radiation from fluoroscopy, as well as from other sources, poses potential health risks to physicians, especially orthopaedic trauma surgeons. The eye lens is known to be sensitive to ionizing radiation. The effect of radiation exposure on eye health of orthopaedic surgeons was investigated. A survey was developed to determine if fluoroscopy has a negative impact on vision and eye health of practicing orthopaedic surgeons. We hypothesize that orthopaedic surgeons with higher exposures to intraoperative fluoroscopy will experience worse eye health than those without such exposure.

Methods: A survey was created to investigate the correlation of fluoroscopy exposure and eye problems. Eye problems were defined as a self-reported history of macular degeneration, keratitis, cataracts, glaucoma, or corrective surgery, or the use of glasses or contacts. SurveyMonkey was then used to distribute the survey electronically and e-mails were sent to members of the OTA and American Orthopaedic Society for Sports Medicine (AOSSM) with a link to complete the survey.

Results: There were 307 respondents with an average age of 49.3 years (range, 30-82 years). 163 respondents reported having eye problems before the age of 30, which likely occurred prior to the start of residency, and they were therefore excluded from the analysis. Of the remaining 144 respondents, 74 (51.4%) developed any eye problems at or after the age of 30 and 70 (48.6%) did not report any eye problems. Respondents who had high cumulative radiation exposure had significantly more eye problems (72% vs 47%; $P = 0.0281$) and significantly more cataracts (20% vs 1.7%; $P = 0.0018$) compared to those who had minimal to moderate cumulative exposure. Also of note, while the majority of respondents were men (94%), 9 women responded to the survey and they were significantly more likely to have eye problems than men (89% vs 46%; $P = 0.0154$). Respondents with eye problems were also significantly older (average age: 54 vs 47; $P < 0.0001$) and had more years post residency (average years: 22 vs 14; $P < 0.0001$).

Conclusion: This survey suggests a correlation between a surgeon's cumulative radiation exposure and the development of eye problems. Efforts to minimize use of fluoroscopy and to protect the eyes from exposure are recommended.

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Body Site–Specific Fluoroscopic Radiation Exposure to the Orthopaedic Trauma Surgeon

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Background/Purpose: Fluoroscopy has become ubiquitous in the orthopaedic trauma setting and has the potential to expose surgeons to large amounts of radiation scatter. This study was performed to determine the amount of exposure experienced by varied body sites during routine orthopaedic trauma procedures and to identify which of these procedures lead to the greatest exposure.

Methods: Three fellowship-trained orthopaedic trauma surgeons at a Level I center each had their radiation exposure monitored during 30 individual cases using dosimeters worn on multiple body sites: dominant hand dorsum, thyroid, chest, abdomen, groin, and thigh (external to any protective radiation garments). Dosimeter sensitivity allowed for measurements of ≥5 mrem; dosimeters were controlled for environmental exposure. As some cases were assumed to produce exposure <5 mrem, each surgeon also monitored cumulative radiation exposure during 25 consecutive cases. Fluoroscopic radiation dose, radiation time, surgeon, and procedure performed were noted for all cases. All information was entered/maintained on a secure database. Dosimeter readings were used to create dose maps that represent radiation exposure experienced during individual and cumulative orthopaedic trauma procedures.

Results: During the cumulative case series, surgeons were exposed to an average of 86 mrem to the thyroid, 100 mrem to the hand, 103 mrem to the chest, 166 mrem to the abdomen, 168 mrem to the groin, and 177 mrem to the thigh. During individual surgical cases, 49% of all dosimeters registered detectable radiation (≥5 mrem). When dosimeters that registered detectable radiation were averaged, the data closely paralleled that of the cumulative case series, with the thyroid experiencing the lowest amount of scatter (13 mrem), followed by chest (14 mrem), hand (16 mrem), abdomen (20 mrem), thigh (26 mrem), and groin (30 mrem). When grouped by procedure site and type, dosimeters from all ankle open reduction and internal fixations (ORIFs) (average fluoro time = 55 sec, average fluoro dose = 59 rad-cm^2) showed undetectable radiation for all body sites except the hand, which registered radiation in 33% of cases. Conversely, all dosimeters utilized during each femoral ORIF/IMN (intramedullary nailing) (average fluoro time = 245 sec, average fluoro dose = 1527 rad-cm^2) showed detectable levels of radiation to every surgeon body site, resulting in the highest average exposures to each body site when compared to all other procedures.

Conclusion: Orthopaedic traumatologists experience significant scatter radiation to all body sites, particularly the abdomen, groin, and thigh, which are at greatest risk during femoral ORIF/IMN. Imaging of the femur and hip requires longer fluoroscopic times and greater fluoroscopic doses, and causes increased backscatter and reflection of radiation from the C-arm source toward the surgeon's abdomen, groin, and thigh. To date, this study provides the most comprehensive survey of radiation exposure to the surgeon during routine ortho-

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paedic trauma procedures. The surgeon can use this information to better understand his or her exposure risks and take appropriate precautions.

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Fluoroscopic Radiation to the Orthopaedic Traumatologist's Hand and Efficacy of a Novel Radiation-Attenuation Product

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Background/Purpose: Fluoroscopy is routinely used by orthopaedic traumatologists. As such, fluoroscopic radiation poses a threat to the surgeon's hands. Although surgeons can avoid direct irradiation, working intimately around the field still exposes the hand to scatter radiation. This study was performed to determine the amount of radiation that the hands of orthopaedic traumatologists experience during routine clinical practice and to evaluate the ability of a novel radiation-attenuating product, only 0.2 mm thick, to decrease this radiation.

Methods: Three fellowship-trained orthopaedic trauma surgeons at a Level I trauma center monitored radiation exposure to their dominant hand during 60 individual trauma cases (20 per surgeon) and 75 cumulative trauma cases (25 per surgeon) requiring the use of large C-arm fluoroscopy. Each surgeon wore two side-by-side dosimeters on the dorsum of their dominant hand for each case, one dosimeter covered with a thin layer (0.2 mm) of a novel radiation-attenuating product and the other adjacent dosimeter without any protection. Both dosimeters were placed within a sterile package and affixed to the surgeon's hand under his or her surgical gloves prior to each case. The dosimeters, which were controlled for environmental exposure, had a minimum radiation detection of 5 mrem. All dosimeters were returned to the manufacturer to determine overall radiation exposure (uncovered) and attenuated radiation exposure (covered).

Results: During cumulative exposure over 25 cases, each surgeon's hand was exposed to an average of 100 mrem (range, 81-128) over the course of 25 cases, with the novel radiation-attenuation product demonstrating the ability to attenuate ≥50% of this radiation exposure (Surgeon A - 58%, Surgeon B - 52%, Surgeon C - 50%). For individual cases, 77% of all dosimeters showed detectable levels of radiation (≥5 mrem) to the hand, ranging from 5 to 69 mrem (average of 16.8 mrem). Average attenuation of radiation by the novel product for all individual cases was 33%. Of the cases that registered undetectable amounts of radiation (<5 mrem) to the hand, >50% consisted of open reduction and internal fixation (ORIF) of ankle, syndesmosis, and distal fibula. All other case types routinely registered detectable radiation to the hand. Greatest exposure was noted with ORIF/IMN (intramedullary nailing) cases of the proximal femur and femoral shaft, which registered an average of 25 mrem to the hand, and ORIF of distal femur and tibial plateau, which registered an average of 12 mrem.

Conclusion: The orthopaedic surgeon's hand is frequently at risk to radiation when using C-arm fluoroscopy. Although surgeons can easily reduce direct irradiation by keeping their hands out of the fluoroscopic field, scatter radiation still poses a danger. Hands are at greatest risk during femoral ORIF and IMN procedures. The novel radiation-attenuating product tested shows the ability to decrease the hand's exposure to scatter radiation by 33% to 58%.

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The Effects of Restraint Type on Pattern of Spine Injury in Children

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Background/Purpose: Despite an increase in proper seatbelt and restraint use, motor vehicle collisions (MVCs) remain a leading cause of morbidity and mortality in children in the United States. The association between restraint use, restraint type, and spinal injury is poorly defined. The purpose of this study is to evaluate the association between restraint type and characteristics of pediatric spine injuries.

Methods: An IRB-approved retrospective study was performed at a Level I pediatric trauma center to identify all patients treated for spinal injury secondary to an MVC between the years of 2003 and 2011. Children under the age of 10 years were included. Restraint type was determined from the trauma intake worksheet and prehospital documentation. Records and radiology studies were reviewed to record the pattern and location of spinal injury. Restraint types were categorized as car seat/booster seat (C/B), 2-point restraint (2P), 3-point restraint (3P), and unrestrained (UR). Rates of restraint use were calculated according to age divided into 2-year intervals. Location and type of spinal trauma was then compared within and between groups using Fisher's exact test and χ^2 analysis.

Results: 113 patients sustained spinal trauma secondary to MVC during the study period. Restraint data were available for 97. 21 of 97 (21.6%) were restrained via C/B, 30 (30.9%) with 2P, 21 (21.6%) with 3P, and 25 (25.8%) were UR. C/B patients sustained a high rates of upper cervical (C) spine (62%) and ligamentous (62%) injuries that were significantly higher than the 2P (10%) and 3P (24%) groups (P <0.001). Children using 2P or 3P restraints sustained a significantly higher rate of thoracolumbar injuries (67% and 62%, respectively) than the C/B (14%) and UR (0%) groups (P <0.001). 2P and 3P passengers also had a higher rate of flexion-distraction (F/D) injuries compared to the C/B and UR groups (P <0.001). No significant difference was found in the rate of F/D injuries between the 2P and 3P groups and there were no other significant differences in injury type or location between these groups. The patients in the UR group sustained a high rate of C-spine (80%) and isolated ligamentous (40%) injuries that were higher than the 2P and 3P groups (P <0.001). Younger children demonstrated higher rates of proper restraint use than older children. 72% of children under 12 months of age traveled properly restrained but only 13% in the 4- and 5-year-old group and 42% in the 8- and 9-year-old group were properly restrained (P <0.01).

Conclusion: While proper restraint use may prevent injury and mortality in MVCs, major spinal injuries occur despite proper use. Characteristic injury patterns and injury locations can be found depending upon the restraint type employed. However, causative assessments are difficult given the differing ages and patient sizes associated with each restraint type.

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Functional Outcome of Supracondylar Elbow Fractures in the Pediatric Age Group: A 3-5–Year Follow-up

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Background/Purpose: Supracondylar elbow fractures (SCEF) are common in the pediatric age group. The return of motion (flexion/extension) has been well documented; however, long-term functional outcome has not been well documented in the literature to date. The purpose of our study is to provide a retrospective evaluation of pediatric SCEF functional outcomes using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. A secondary goal was to determine if there were clinical predictors of the outcome (such as gender, age at injury, years out of injury, type of fracture, weight, right or left extremity, surgery, or general medical condition) such that one could predict if these parameters could predict long-term functional outcomes.

Methods: We retrospectively reviewed 158 patients who presented to our tertiary care pediatric emergency department with supracondylar elbow fractures between January 2005 and December 2009. A chart review was undertaken to review several clinical parameters including the following: age, sex, Gartland classification of fracture severity, weight, comorbidities, operative or nonoperative treatment intervention, and postoperative physiotherapy. A DASH questionnaire was performed in 2012 by the parent or the child if they were old enough to do so. A multiple linear regression analysis was performed to determine the significance of the clinical parameters as they related to the DASH score for functional outcome.

Results: In this study, pediatric supracondylar fractures have a good functional outcome using the DASH questionnaire (with an average score of 0.77 ± 2.10 [standard deviation]). By fracture type, the following DASH scores were obtained: type 1, 0.45 ± 2.20; type 2, 1.09 ± 1.70; and type 3, 1.43 ± 2.40. There was no statistical difference in functional outcome regardless of gender ($P = 0.070$), age at injury ($P = 0.958$), type of fracture ($P = 0.135$), weight ($P = 0.593$), right or left extremity ($P = 0.262$), or surgery ($P = 0.520$). Also, our interobserver agreement to indicate the reproducibility of the Gartland classification for pediatric SCEF was calculated using weighted Fleiss kappa. Our calculated kappa score was 0.76, which represents good interobserver reliability.

Conclusion: Our study demonstrates good functional outcomes can be expected with SCEF in the pediatric population using the DASH. Most patients report no statistically significant functional limitation to physical function or symptoms following SCEF. No limitations in function or technique in the optional module (sports or performing acts) were detected despite the Gartland fracture classification, age, weight, extremity involved, or gender. Overall, regardless of age at injury, gender, weight, or surgical or nonsurgical intervention, pediatric SCEF have no functional interference with normal social activities, sports or performing arts, activities of daily living (including self care), and no functionally limiting symptoms.

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Pediatric Talar Fractures: Clinical Outcomes and Complications

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Background/Purpose: Outcomes of pediatric talar fractures are minimally reported in the literature. Because of the remodeling potential in the immature foot, treatment is usually based on the severity of the fracture and the age of the child. Due to higher activity levels and high-intensity sports, more complex fractures of the foot, including the talus with coexisting injuries, are seen. Even though severe chronic complications are less likely in pediatrics than in adults, osteonecrosis and arthrosis of the surrounding joints occur. Resulting pain syndromes and decreased mobility may need further treatment such as arthrodesis. The purpose of this study was to determine the clinical and radiographic outcomes following pediatric talar fractures.

Methods: From 2002 to 2010, 52 consecutive children with 54 pediatric talar fractures were retrospectively evaluated. 26 children with 28 fractures were available for follow-up >6 months. Those patients with follow-up <12 months (6) had no signs of avascular necrosis (Hawkins sign on a radiograph) on their final follow-up. 20 patients with 22 fractures had follow-up >12 months (mean, 40.3 months; range, 14-95). Associated injury, conservative and operative treatment, and complications were recorded. Final clinical and radiographic outcome concerning range of motion (ROM), pain, pain medication, shoe wear, nonunion, infection, osteonecrosis (ON), arthrosis, and arthrodesis were determined.

Results: Age averaged 14.2 years (range, 3.6-18.0). 18 injuries (64%) were caused by high-energy trauma. Two fractures (7.1%) were open. 19 children (73.1%) had associated injuries. Fractures were classified according to Marti-Weber as 12 (42.9%) Type 1, 6 (21.4%) Type 2, 3 (10.7%) Type 3, and 7 (25.0%) Type 4 fractures. Neck fractures were classified according to Hawkins as 6 (21.4%) Type 1, 3 (10.7%) Type 2, and 5 (17.9%) Type 3 fractures. Five fractures (17.9%) were treated conservatively and 23 (82.1%) surgically, with open reduction and internal fixation of 20 fractures. External fixation was performed in two fractures, Kirschner-wire fixation in one, and subchondral drilling in one. Two open fractures had débridement and closure; one lawn mower injury required repeat débridement. Nonunion occurred in three fractures (10.7%), one talar neck and two talar dome fractures, which resulted in an osteochondrosis dissecans (OD). Nonunion was treated with a second open reduction and internal fixation. ODs were either treated with subchondral drilling or osteochondral allograft transplantation. ON of the talus occurred in three fractures (10.7%), all neck fractures (1 Hawkins Type 1 and 2 Type 3). One ON had no further treatment, one subtalar and ankle fusion, and one talar dome excision with allograft reconstruction were performed. Seven ankles (25.0%), eight subtalar joints (28.6%), and seven talonavicular joints (25%) showed mild to severe signs for arthrosis. One ankle fusion and one subtalar with ankle fusion were present. Ankle ROM averaged 19.5° (range, 0-35) dorsiflexion and 37.1° (range, 0-45) plantar

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flexion. Ten subtalar joints had <50% ROM. 12 children (46.2%) had persistent pain on their final follow-up and 4 (15.4%) used pain medication (3 nonsteroidal anti-inflammatories, 1 narcotics) regularly.

Conclusion: Pediatric talar fractures are severe injuries of the foot. Although remodeling potential of the foot is present, severe chronic complications do occur and can require joint arthrodesis even in the pediatric population. As in adults, anatomic reduction and internal fixation is necessary to reduce the rate of long-term complications.

See pages 91 - 132 for financial disclosure information.

Cell Saver Use in Acetabular Surgery: Does Approach Matter?

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Background/Purpose: Open reduction and internal fixation of acetabular fractures can lead to large volumes of intraoperative blood loss. Intraoperative autologous transfusion (IAT) by means of Cell Saver (CS) technology is routinely utilized during surgery, but at a monetary cost. The primary aim of this study was to determine if IAT rates and volumes were significantly different between anterior versus posterior approaches to the acetabulum, as well as to ascertain if blood loss was different between the two approaches. These data could potentially aid surgeons to determine when CS should be used for acetabular fracture surgery.

Methods: 145 consecutive acetabular fractures treated either with an anterior or a posterior approach were included in this retrospective single-center cohort study. IAT was used in all cases. Assessment included: demographic data, ISS, American Society of Anesthesiologists (ASA) score, fracture classification, approach used, estimated intraoperative blood loss, CS blood returned, blood products administered during procedure, length of procedure, postoperative blood products within 48 hours, and postoperative blood products administered until discharge.

Results: 65 fractures were treated through an anterior approach and 80 fractures from a posterior approach. Mean intraoperative blood loss was 786 mL for the anterior approach versus 485 mL for posterior approach ($P = 0.004$). CS blood was returned in 23 of 65 anterior cases and 6 of 80 posterior approach cases ($P = 0.04$). Mean CS return was 141 mL for anterior approach versus 28 mL for posterior approach, when all cases were included ($P = 0.001$). The mean CS blood return for the 23 anterior cases in which blood was returned to the patient was 398 mL, and 379 mL for the 6 cases in which blood was returned using the posterior approach ($P = 0.83$). Subgroup analysis identified male gender and anterior approach as the only risk factors for elevated blood loss and CS blood return.

Conclusion: Patients undergoing acetabular fracture surgery have significantly increased blood loss when an anterior approach is used compared to a posterior approach. Anterior approach cases utilize CS blood return at a statistically significant higher rate compared to posterior approach cases. Potential cost-saving measures can be utilized by preferentially using IAT for acetabular fractures that require an anterior approach.

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Is Preoperative XRT as Effective as Postoperative XRT for the Prevention of Heterotopic Ossification in Acetabular Fracture Patients?

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Background/Purpose: Heterotopic ossification (HO) is a well-documented complication following surgical treatment of acetabulum fractures. The most common forms of HO prophylaxis include indomethacin and/or single-dose external beam radiation (XRT) given postoperatively. The purpose of this study was to determine if a significant difference would be observed in the occurrence and severity of HO following the administration of prophylactic XRT preoperatively compared to postoperatively for acetabular fracture patients treated with open reduction and internal fixation via a Kocher-Langenbeck approach.

Methods: 105 patients (107 acetabular fractures) surgically treated through a Kocher-Langenbeck approach for an acetabulum fracture were identified from our prospectively collected acetabular fracture database. The patients were divided into two groups based on whether they received preoperative XRT (Group PRE) or postoperative XRT (Group POST) for HO prophylaxis. Demographic, injury, and treatment data were abstracted from the prospectively collected acetabulum fracture database. Radiographs taken at a minimum of 6 months postoperative were reviewed by two independent investigators and assigned a Brooker grade. In cases where the evaluators were in disagreement a third reviewer adjudicated. The development of HO was further analyzed based on clinically insignificant (Grades 0, I, II) and clinically significant (Grades III and IV).

Results: Group PRE had 34 patients with 36 acetabular fractures (29 males and 5 females) with an average follow-up of 20.4 ± 23.0 months and Group POST had 71 patients (53 males and 18 females) with an average follow-up of 20.0 ± 19.3 months. Groups PRE and POST were similar in terms of gender, mechanism of injury, hip dislocation rate, associated injuries including neurological injuries, operative time, estimated blood loss, treatment interval, ISS, and Glasgow coma scale. A slightly longer interval from injury to surgery was seen in group PRE; however, this difference did not reach statistical significance (PRE: 5.6 ± 3.1 days; POST: 4.5 ± 3.8; $P = 0.061$). The presence of HO between the two groups was similar (PRE: 22.2% [8 of 36]; POST: 26.8% [19 of 71]; $P = 0.582$). In terms of HO severity, 2 of 36 patients in Group PRE (5.6%) and 3 of 71 patients in Group POST (4.2%) developed clinically significant grade III HO, but no patients in either group developed grade IV HO ($P = 1.000$).

Conclusion: In this series, a significant difference in the occurrence and severity of HO was not observed when comparing preoperative XRT to postoperative XRT. However, given the relatively low incidence of HO in this population, the possibility of a type II error must be considered.

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Anatomic Determinants of Sacral Dysmorphism and Implications for Safe Iliosacral Screw Placement

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Background/Purpose: Upper sacral segment dysplasia (USSD) increases the risk of cortical perforation during iliosacral screw (ISS) insertion. Dysmorphic sacra have altered orientation and cross-sectional area of the safe corridor for ISS placement; however, no validated definition of this anatomic variation exists. We hypothesize pelves can be quantitatively grouped by such anatomic measurements as well as racial and anthropometric parameters.

Methods: 104 CT scans from uninjured pelves were analyzed. 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 and perpendicular to this osseous corridor to assess the presence, cross-sectional area, and length of a transsacral corridor of 10-mm diameter in the upper and second sacral segments. 3-dimensional volumetric reconstructions were used to determine the presence of qualitative characteristics of USSD: (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. Multivariable analyses were used to identify combinations of factors that explain variability in anatomy and classify dysmorphic from nondysmorphic pelves.

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Results: Cluster analysis revealed three discrete pelvic phenotypes based on the maximal length of a 10-mm–wide area centered on safe corridor axis in the upper two sacral segments. These included: (1) a long safe corridor (>120 mm) in both segments (nondysmorphic), 2) a short safe corridor (<120 mm) in the upper sacral segment and a long safe corridor in the second sacral segment (dysmorphic), or (3) a short safe corridor in both segments. 41% of pelves fell into the dysmorphic cluster. Even after accounting for imperfect agreement, each of the five characteristics tested were significantly more frequently recorded (P <0.007) for subjects in this dysmorphic cluster than in those where long safe corridors could be mapped in both sacral segments. Both quantitative features (safe corridor cross-sectional area, coronal and axial orientation) as well as race (Latin race predominantly) explained the major morphologic variations seen in this cohort of pelves. Using logistic regression, we derived a dysmorphic score (DS) based on the sum of the upper sacral segment coronal and axial angulation (DS = CA + 2AA). There were no patients in whom a transsacral corridor was present when the dysmorphic score was greater than 70.

Conclusion: USSD is associated with angulated and narrow bony corridors. In this radiographic study of 104 uninjured pelves, 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. The five qualitative characteristics of dysmorphism were present with significantly greater frequency in pelves with a short safe corridor. Grouping of patients by the length of a safe

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osseous corridor allows a clinically relevant and quantitative description of sacral dysmorphism. The major determinants of these groupings are upper sacral corridor coronal and axial orientation. Reformatting CT scans to allow measurements of these angles and use of the dysmorphic score can aid in preoperative planning of safe iliosacral and transsacral screw insertion for stabilization of the posterior pelvic ring.

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It's the Corridor Height Limiting Safe Transsacral Implant Positioning

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Purpose: Knowledge about the anatomy of the transsacral corridor is crucial for the placement of transsacral implants. These implants are used in acute sacral fractures but also increasingly in sacral insufficiency fractures. The goal of this study was to quantify the transsacral corridors in Europeans and Japanese.

Methods: We studied at total of 156 CT scans of intact pelves from 92 European (48 females, 44 males; mean age, 61.5 years, standard deviation [SD] ± 11.2) and 64 Japanese adults (29 females, 35 males; mean age 74.3 years, SD ± 13.6). Semiautomated segmentation was performed to compute surface models of the sacra and to create a statistical model with all sacra included. The measurements of the trans-sacral corridors were taken in a semi-transparent lateral view (Figure 1). A maximal diameter of <12 mm was considered as critical and <8 mm as impossible for transsacral implant positioning. Standard descriptive statistics, unpaired *t* test for scaled data, and the χ^2 test for nominal data were made.

Results: The vertical diameter of the transsacral corridor S1 ranged from 1.2 to 21.8 mm (mean 12.4 mm, SD ± 4.9); the horizontal diameter S1 was 5.8 to 31.2mm (mean 23.9, SD ± 4.9). The vertical diameter was significantly higher in Europeans ($P = 0.02$, mean 13.1 vs 11.2 mm) and in males ($P = 0.01$, 13.3 vs 11.4 mm). On the level S2 the transsacral corridors demonstrated a vertical diameter ranging from 8.1 to 19.2 mm (mean 14.0 mm, SD ± 2.4) and horizontal size 11.6 to 23.9 mm (mean 17.6, SD ± 2.3). The vertical diameter S2 was significantly higher in males ($P = 0.01$, 14.4 vs 13.5 mm). The limiting factor was always the vertical height. 75 of 156 (48%) of the transsacral corridors S1 were critical in their vertical diameter (<12 mm), whereas 19% (30 of 156) were critical in S2. Impossible (<8 mm) were 21% (33 of 156) on level S1 and none in S2. Japanese and females had significantly more critical corridors on S1 level ($P = 0.02$ and 0.03, respectively); females showed also significantly more critical corridors in S2 and impossible in S1 ($P = 0.03$ and 0.001, respectively).

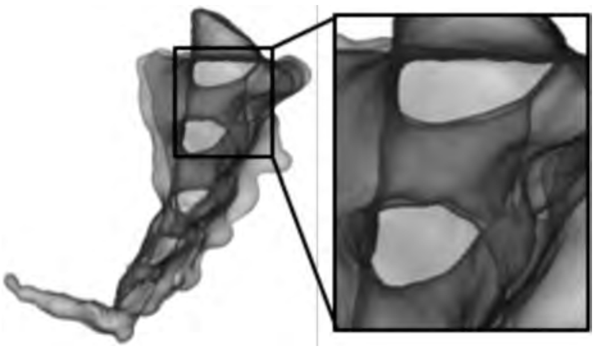

Figure 1: Semi-transparent lateral view of a sacrum with clearly visible transsacral corridors.

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Conclusion: In a large number of sacra there was only limited space for placing transsacral implants, with the vertical corridor diameter being the decisive criterion. The Japanese and females revealed smaller corridors on level S1. Interestingly on level S2, implant positioning was always possible. Its height showed a lower variability than in S1. A thorough study of the individual sacral anatomy is therefore compulsory in the preoperative planning to decide the number, position, and choice of implant. Further studies have to be undertaken to detect critical transsacral corridors preoperatively.

See pages 91 - 132 for financial disclosure information.

Functional Outcomes in Women Following Pelvic Ring Fractures

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Background/Purpose: Pelvic fractures are severe and increasingly common injuries, the brunt of which are disproportionately borne by patients in the prime of their productive and reproductive lives. High rates of musculoskeletal and sexual dysfunction have been reported in this population, often leading to a substantial decrease in quality of life. Nevertheless, the true incidence and effect of this impairment remains unclear, particularly in the female population. This prospective matched case-control study explores specific musculoskeletal and sexual functional outcomes among women after high-energy pelvic fracture, while comparing their experiences to those of women after high-energy lower extremity fracture.

Methods: Two groups of women aged 18 years and older were recruited from the fracture clinic of a Level I trauma center between January 1999 and August 2012. Patients with operatively and nonoperatively treated pelvic ring fractures comprised the subject group. Patients with high-energy lower extremity fractures comprised the control group. Participants completed two well validated, self-administered functional outcomes questionnaires: the Short Musculoskeletal Functional Assessment (SMFA) and the Female Sexual Function Index (FSFI). Demographic information, ISS, and injury profiles were collected from questionnaire responses and hospital records. Pelvic fractures were radiographically evaluated and classified into the OTA/Tile scheme using initial trauma films and CT scans. Using the Statistical Analysis Software (SAS) package, cases and controls were matched on a one-to-one ratio according to age within 10 years, ISS ≤17 or >17, and follow-up duration within 3 months if less than 2 years. Follow-up durations greater than 2 years were matched as a single group. Outcomes for each domain of the SMFA and FSFI, as well as overall score in each questionnaire, were compared between the matched pairs using paired *t* tests with a *P* value of 0.05.

Results: 68 matched pairs were obtained from a total of 80 subjects. Average subject and control ages (48 and 46 years), and ISS (16 and 13) were not significantly different. Age ranges among subjects (19-89 years) and controls (19-81 years) were also statistically similar. Average follow-up duration was 49 months in the subject group and 34 months in the control group. The majority of pelvic ring fractures were classified as OTA/Tile type B injuries. Tibia and femur fractures comprised the majority of the control population's injuries. No significant differences in SMFA scores were detected between subjects and controls in both specific domains and overall scores. Similarly, domain=specific and overall FSFI scores showed no significant differences between the subject and control groups. No identifiable trend was apparent in any domain of the FSFI or SMFA.

Conclusion: High-energy pelvic fractures have been associated with significantly increased rates of musculoskeletal and sexual dysfunction. Using validated self-assessment measures, this prospective case-control analysis was unable to demonstrate any significant difference

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in the outcomes of high-energy pelvic trauma victims, and a demographically similar group of lower extremity trauma patients. These findings suggest that late posttraumatic musculoskeletal and sexual dysfunction may be more closely related to the energy of the trauma in question, rather than the specific nature of the injuries it inflicts.

See pages 91 - 132 for financial disclosure information.

Radiographic Follow-up of APC-II Pelvic Ring Injuries Treated With Symphyseal Plating and Iliosacral Fixation

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Background/Purpose: Treatment of anterior-posterior compression (APC)-II (61-B1.1 and 61-B3.1) injuries is controversial. Anterior fixation alone is common and depends on the partially injured posterior ligaments for posterior stability. Previous studies have reported high (25%) failure rates with anterior fixation alone. Many of these injuries at our institution are treated with a multiple-hole anterior plate and typically augmented with iliosacral screws posteriorly. We hypothesize that additional fixation of the posterior pelvic ring in APC-II injuries will decrease postoperative displacement from fixation failure and reoperations compared to published rates.

Methods: Evaluation of our trauma database from 2002 to 2008 identified 856 patients with symphyseal disruptions. Those with additional pelvic ring injuries affecting pelvic ring stability or without definitive anterior plate fixation were excluded from the study. Injury radiographs and CT scans of each patient were independently reviewed by 4 experienced orthopaedic traumatologists to identify 61-B1.1 and 61-B3.1 patterns. If 3 of the 4 reviewers agreed on the same injury pattern, and if radiographic follow up was at least 3 months postoperative, the patient was included in the study. 53 patients were included. Measurements were made from their injury AP, postoperative CT, scout AP, and latest follow-up inlet/outlet radiographs. The quality of reduction was evaluated with AP projections, measuring horizontal displacement, pelvic asymmetry, and the pelvic deformity index (Keshishyan system). Follow-up inlet and outlet views allowed measurement of horizontal and vertical displacement, respectively.

Results: There were 38 61-B1.1 and 15 61-B3.1 injuries, including 51 males, and 2 females. Eight were treated with anterior plates alone while 45 had additional posterior iliosacral screw fixation. No transiliac, transsacral screws were placed. Symphyseal displacement was 30.52 mm (range, 10.20-89.60 mm) at time of injury and 7.53 mm (range, 2.35-13.33 mm) after surgery. Pelvic asymmetry and deformity index (Keshishyan measurements) at time of injury improved from 8.86 to 5.74 and 0.03 to 0.02 after surgery, respectively. Follow-up symphyseal widening was 9.17 mm (range, 3.20-19.70 mm), an average loss of reduction of 1.64 mm. Follow-up hemipelvis vertical displacement was 1.49 mm (range, 0-11.00 mm). 29 patients (54.7%) had their anterior plates break or an anterior screw break or back-out, but this did not lead to increased displacement. One of 8 patients with anterior fixation alone required revision for loss of reduction 13 days after surgery (revision rate 12.5%) and one of 45 patients with anterior and posterior fixation required revision 9 days after surgery (revision rate 2.2%). Three other patients required return to the operating room—one for superficial infection, one for heterotopic bone excision around the anterior plate and one for removal of backed-out symphyseal screw. No posterior fixation was revised.

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Conclusion: Pelvic ring injuries represent a spectrum of injury. Anterior fixation of APC II (61-B1.1 and 61-B3.1) injuries may be inadequate fixation, prone to loss of reduction and need for revision surgery. With posterior pelvic stabilization, anterior fixation is still susceptible to breakage. However, the addition of posterior ring stabilization may prevent loss of reduction and decrease the need for reoperation.

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The Effect of Pelvic Embolization on Wound Complications After Surgically Treated Pelvic and Acetabular Fractures

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Purpose: We sought to determine if selective and nonselective pelvic embolization for hemorrhage results in a higher incidence of wound complications in surgically treated pelvic and acetabular fractures compared to patients that do not require embolization.

Methods: Consecutive patients with pelvic and acetabular fractures were identified at a single Level I trauma center from 2008 to 2011. All charts and radiographs were reviewed to determine fracture pattern, presence and type of pelvic angiography (selective versus nonselective), type of definitive fracture fixation (approach, surgical time, hardware), postoperative complications, and mortality. Additional variables that were assessed include age, body mass index (BMI), and ISS. Patients were divided into 2 cohorts: surgically treated fractures that underwent preoperative pelvic angiography, and surgically treated fractures that did not undergo pelvic angiography. The primary outcome measurement was the incidence of postoperative wound complications including surgical site infection and pelvic soft-tissue necrosis. Multivariate analysis was performed to elucidate associations between wound complications and possible confounding variables including age, BMI, ISS, and fracture pattern.

Results: 443 pelvic and acetabular fractures were identified, of which 99 were treated surgically. Of the surgically treated patients 80 did not undergo preoperative embolization and 19 did require preoperative embolization for life-threatening hemorrhage. Demographic variables were similar between groups (all $P > 0.05$). The average age of the nonembolized group was 35 years, and 65% were male. The average age of the embolized group was 33 years, and 63% were male. No difference in mortality was identified between patients requiring pelvic embolization compared to patients who did not undergo embolization (6.7% versus 6.0%, respectively). Fracture patterns were similar between the groups, with acetabular fractures comprising the majority of fractures in both groups (embolized = 54%, nonembolized = 26%). The remainder of fractures in each group consisted of a heterogeneous group of anterior-posterior compression, lateral compression, and vertical shear pelvic injuries. Average follow-up was 5 months (range, 3-11 months). The incidence of wound complications was significantly greater in patients who required pelvic embolization prior to definitive treatment. The overall incidence of wound complications in the embolized group was 37% (7 of 19 patients), compared to 2.5% (2 of 80 patients) in the nonembolized group ($P = 0.0004$). Of the patients who underwent preoperative embolization and suffered a wound complication, 4 had nonselective embolization and 3 had selective embolization. 6 of 7 wound complications after embolization were located in the posterior pelvis with 1 in the anterior inguinal region (4 of 7 gluteal necrosis, 3 of 7 infection of posterior incision). After adjusting for possible confounding variables such as age, BMI, ISS, and fracture pattern, the association between embolization and wound complications remained, with a relative risk of 14.7 (95% confidence interval: 3.3-63).

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Conclusion: Previous studies have documented higher incidences of wound complications with surgically treated acetabular fractures after embolization. We have shown this risk to be true for surgically treated pelvic fractures as well. Surgeons should be aware of the increased risk of wound complications in the treatment of both pelvic and acetabular fracture after pelvic embolization.

Incidence of Pelvic Arterial Bleeding and Complications in Patients Requiring Embolization and Pelvic/Acetabular Surgery

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Purpose: This study was undertaken to evaluate pelvic trauma patients with hemodynamic instability, identify pelvic arterial injury patterns and determine the incidence of complications in patients requiring pelvic/acetabular surgery.

Methods: From November 2005 to July 2012, 1582 consecutive trauma patients with pelvic fractures were admitted to a Level I trauma center. Of those, 157 patients presenting with or developing hemodynamic instability underwent pelvic angiography (PA) with or without embolization in adherence to the Western Trauma Association algorithm for management of pelvic fractures. Hemodynamic instability was defined as systolic blood pressure <90 mm Hg, significant transfusion requirement (4-6 Units), or significant base deficit (<–6) despite early resuscitation efforts. Embolization was performed at the discretion of the interventional radiologist with either gel foam pledgets or coils. Any active arterial extravasation was noted and the anatomic location recorded.

Results: The 157 pelvic injury patterns consisted of the following OTA classifications: 61A2 (6), 61A3 (1), 61B1 (16), 61B2 (21), 61B3 (7), 61C1 (56), 61C2 (21), 61C3 (12), 62A2 (4), 62A3 (3), 62B1(6), 62B2(7), 62B3(1), 62C1 (5), 62C2 (4), and 62C3 (3). 16 patients had both pelvic and acetabular injuries and therefore were accounted for separately. Patient age averaged 46.6 years (range, 14-97). ISS averaged 33.0 (range, 4-75). There were 11 open and 146 closed fractures. Mechanism of injury consisted of motor vehicle collision (71), pedestrian versus auto (35), motorcycle collision (18), fall from heights (13), pedestrian versus train (3), all-terrain vehicle (3), pedestrian versus tractor (6), bicycle versus auto (3), and other (5). 117 out of 157 patients underwent bilateral internal iliac artery embolization. 22 patients underwent unilateral internal iliac artery embolization and 18 underwent no embolization. 85 (54%) of 157 patients had documented arterial injury with 78 showing active arterial bleeding. The most common artery involved was the obturator artery/branches (39), followed by the superior gluteal (SGA) (28), lateral sacral (17), internal pudendal (11), posterior division internal iliac proximal to SGA (5), iliolumbar (5), internal iliac (4), anterior division internal iliac proximal to the obturator (2), and other (5). Nine patients had two or more ipsilateral bleeding vessels. 37 (24%) of the 157 patients died during the initial hospital stay. 61 of 157 patients underwent pelvic and/or acetabular surgery, and 60 of those underwent embolization. 26 of those 60 (43%) had complications while only 23 of 79 patients (29%) who underwent embolization without pelvic or acetabular surgery had complications. Complications recorded included tissue necrosis, infection, fracture nonunion, urinary symptoms, sexual dysfunction, and amputation.

Conclusion: Hemodynamically unstable patients with pelvic/acetabular fractures have a high incidence of arterial injury. Obturator artery was the most commonly injured vessel followed by the SGA. Patients undergoing embolization and pelvic/acetabular surgery appear to have an increased complication rate compared to patient undergoing similar surgery without prior embolization.

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Anatomical Relationship Between the Superior Gluteal Vessels and Nerve at the Greater Sciatic Notch: Implications for Controlling Hemorrhage During Surgery

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Purpose: The purpose of this study is to define the positional anatomy of the superior gluteal blood vessels and nerve (SGVAN) at the greater sciatic notch in a human cadaver model.

Methods: 23 embalmed human cadaver hemipelvi were dissected. The greater sciatic notch and superior gluteal (SG) neurovascular structures (SGVAN) were exposed via the posterior approach to the sacrum/sacroiliac joint. The gluteal musculature was mobilized to expose the greater sciatic notch and posterior ilium. The SGVAN were identified in the greater sciatic notch above the piriformis and carefully traced superficially. Branches of the SGVAN and their anatomical relationship to each other and to bone were recorded in a computer database.

Results: In the notch, SG arteries comprised a single vessel in 18 of 23 specimens (78%) with all of these dividing at varying distances (1-3.5 cm) along the lateral ilium after exiting into superior and inferior branches. In the other 5 specimens (22%) there was branching of the artery deep or in the notch resulting in two similar-sized vessels that exited following a similar path as the others along the outer ilium. Deep branches of the SG artery were contiguous with periosteum of the bony notch in all specimens. The SG vein was characterized by two or more vena comitantes, very closely associated with the artery and its branches and for the purposes of study vessels were considered together. SG nerve branching was seen in the greater sciatic notch in all specimens, including a superior branch exiting cranial to the SG artery and an inferior branch exiting caudal (on bone) or caudal-superficial to the SG artery and vein. In the two specimens, there was a "spray" pattern where numerous branches of the nerve were present that notably intermingled with the vessel branches. The inferior-most SG nerve branch was directly adjacent to the bony notch's periosteum in 15 of 23 specimens (65%).

Conclusion: The SGVAN, which supply vascularity and innervation to important hip abductor muscles, are clearly at risk in patients undergoing acetabular or pelvic fracture surgery. One performing surgery along the acetabulum's posterior column or during posterior approach to the sacroiliac joint would expect to encounter a major branch(es) of the SG nerve before encountering the SG artery or vein in all cases. As such, in cases where there is bleeding from the notch, use of cautery, ligature, or clips should be avoided or else the SG nerve branches are likely to be injured. Iatrogenic injuries to the SGVAN may be prevented if the surgeon is cognizant of the local anatomy/anatomical relationship of these structures and employs alternative practice (iec packing or use of a procoagulant material) if unforeseen hemorrhage is encountered.

See pages 91 - 132 for financial disclosure information.

A Survey of High-Energy Acetabular Fractures in Elderly Patients

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Purpose: In spite of the increasing prevalence of trauma in the elderly, there is a paucity of literature on elderly individuals who have sustained acetabular fractures, and even less on those associated with high-energy trauma. The purpose of this study is to compare the clinical outcomes and mortality rates among elderly patients who present with high-energy versus low-energy acetabular fractures.

Methods: Between January 2005 and June 2012, 116 patients 65 years of age or older were treated for acetabular fractures at our regional Level I trauma center. Patient and injury characteristics, management details, and mortality data were collected. The patients were then stratified and compared by low-energy (LE; fall from a standing height) and high-energy (HE; automotive trauma, high fall, crush) mechanisms to determine if there were trends in the care, complication rate, or mortality. Binary comparisons were made using a Fisher exact test and ordinal or continuous variables were analyzed with a Mann-Whitney U test.

Results: The HE cohort (n = 46) was younger (74.87 ± 8.2 years vs 80.86 ± 8.2 years, P <0.001), had a higher male predominance (74% vs 53%, P = 0.0318), less comorbidities (average 1.26 vs 2.09, P <0.01), more associated injuries (average 4.7 vs 0.87, P <0.001), and greater ISS (20.21 ± 15.3 vs 6.34 ± 3.5, P <0.001) than the LE cohort (n = 70). The fracture patterns were similar between the groups, with the majority of patients sustaining anterior column, associated both-column, or anterior column/posterior hemitransverse (AC/PHT) fractures (HE 55% vs LE 61%). In the HE group, a greater percentage of patients received an operative intervention (50% vs 29%). 30-day mortality (30% vs 2%, P = 0.0001) was significantly higher in the HE group; however, the 1-year mortality rates (33% vs 23%, P = 0.28) were not found to be significantly different between the two groups. 63% of the patients in the LE group who were nonambulatory at 6 months died within the first year of their injury. No patients in the HE group who were able to ambulate at 6 months died within 1 year of follow-up. Of the 23 patients in the HE cohort who underwent operative management, the 1-year mortality rate was only 9%.

Conclusion: Elderly patients who sustain acetabular fractures as the result of HE mechanisms are a distinctly different group than elderly patients with lower-energy injuries. Early mobilization should be the primary treatment goal for senior patients with acetabular fractures; however, future clinical research is needed to determine the patient and fracture variables best indicated for operative treatment, and what type of operative treatment, in order to decrease the high mortality rate in this growing elderly population.

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Femoral Nerve Palsy After Pelvic Fractures Treated With Anterior Internal Fixator: A Previously Unreported and Potentially Devastating Complication

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Background/Purpose: The surgical treatment of pelvic injuries has evolved recently to include the use of an anterior internal fixator–supra-acetabular placement of pedicle screws linked by a subcutaneous bar and clamps. To date few complications have been reported associated with the technique. We present a small case series including seven femoral nerve palsies after application of an internal fixator in an attempt to highlight this potentially devastating injury and ultimately limit its occurrence in the future.

Methods: This is a retrospective review of medical records and diagnostic imaging from five Level I and II trauma centers (tertiary referral hospitals). Five patients with anterior pelvic ring injury treated with an internal fixator were evaluated clinically and with electromyography (EMG), including two patients whoexperienced bilateral femoral nerve palsies.

Results: Three of the five patients evaluated (four nerves) were performed by fellowship-trained orthopaedic trauma surgeons, and the other two were seen in follow-up after surgery at an outside facility. Four nerve injuries in three patients were immediately identified in the recovery room (including one patient with an associated femoral artery occlusion) while another conspicuously occurred late (6 months) after the patient returned to work standing for 10 hours a day; the timing of the others is unclear. All fixators were removed (range, 2 hours to 3 weeks after application). Three of five patients (5 of 7 nerves) had little or no improvement of nerve function at early (4- to 6-month) follow-up, and only one nerve had resolved completely.

Conclusion: Application of an internal fixator for treatment of anterior pelvic ring injury carries the risk of a potentially devastating femoral nerve(s) injury. Despite early implant removal, all five patients (6 nerves) had significant residual quadriceps weakness and disturbance of the thigh's skin sensation at the time of final follow-up.

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Inguinal Abnormalities in Male Patients With Acetabular Fractures Treated Using an Ilioinguinal Exposure

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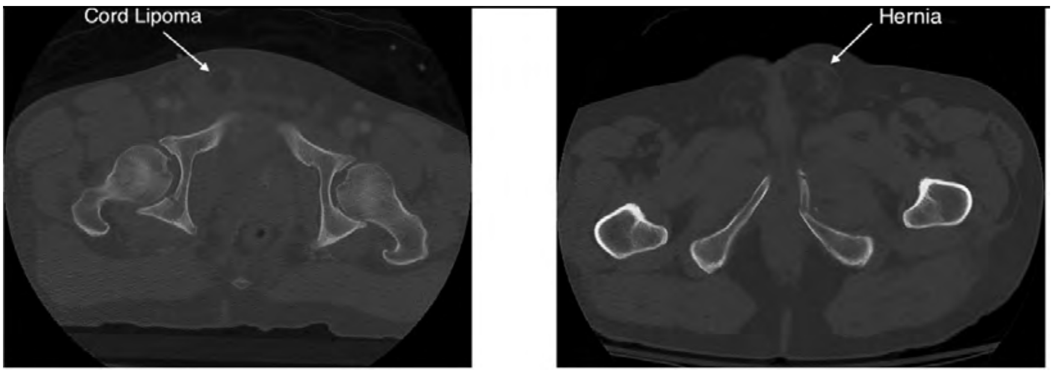
Background/Purpose: Surgeons performing an ilioinguinal exposure for acetabular fracture surgery need to be aware of aberrant findings such as inguinal hernias and spermatic cord lesions, which increase the complexity of the exposure and closure. The purpose of this study is to report these occurrences in a clinical series of adult males undergoing acetabular fracture fixation and a series of adult male cadavers. The secondary aim is to characterize these abnormalities to aid surgeons in detecting these abnormalities preoperatively and coordinating a surgical plan with a general surgeon.

Methods: The clinical study was a retrospective review of treated acetabular fractures through an ilioinguinal approach over a 3-year period. Incidence of inguinal canal and spermatic cord abnormalities requiring general surgery consultation were identified. Corresponding CT scans were reviewed and radiographic characteristics of the spermatic cord abnormalities and/or hernias were noted. In the cadaveric study, 18 male cadavers were dissected bilaterally using an ilioinguinal exposure. The inguinal canal and the contents of the spermatic cord were identified and characterized.

Results: In the clinical study, 5 of 87 patients (5.7%) had spermatic cord lesion and/or inguinal hernia requiring general surgical intervention: 2 indirect inguinal hernias, 1 isolated cord lipoma without associated bowel herniation, and the 2 remaining patients had both direct inguinal hernias and cord lipomas. Preoperative pelvic CT scan review of all 5 patients identified abnormalities noted intraoperatively. Cord lipomas were visualized as enlargements of the spermatic cord with homogeneous density. Hernias were visualized as enlarged spermatic cords with heterogeneous density. In the cadaver study, 11 of 36 specimens studied (31%) had spermatic cord and/or inguinal canal abnormalities: 1 cadaver, bilateral indirect inguinal hernias; 3 cadavers, bilateral spermatic cord lipomas; and 3 cadavers, unilateral spermatic cord lipomas. Average cord diameter in those with abnormalities was 24.9 mm (range, 15-28) compared to 16 mm (range, 11-22) in normal cords, which was statistically significant.



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Conclusion: The clinical and cadaveric findings emphasize the importance of understanding inguinal abnormalities and the value of detecting them preoperatively. The preoperative pelvic CT scans were highly sensitive in detecting inguinal abnormalities. When abnormalities are detected, the orthopaedic surgeon must coordinate the operative plan with a general surgeon.

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Δ Prevalence of Abuse and Intimate Partner Violence Surgical Evaluation (PRAISE): A Multinational Screening Study in Orthopaedic Fracture Clinics

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Purpose: Intimate partner violence (IPV) is the leading cause of nonfatal injury to women. Musculoskeletal injuries, often seen by orthopaedic trauma surgeons, represent the second most common manifestation of IPV. We aimed to determine the 12-month and lifetime prevalence of IPV in women presenting to orthopaedic fracture clinics.

Methods: The PRAISE investigative team (80 investigators) conducted a cross-sectional study of 2945 female participants at 12 orthopaedic fracture clinics in Canada, the United States, the Netherlands, Denmark, and India. Participants anonymously answered direct questions about IPV and completed two previously validated questionnaires. We completed a multivariable logistic regression analysis to investigate risk factors associated with IPV.

Results: One in six women (16.0%, 95% confidence interval [CI]: 14.7%-17.4%) disclosed a history of IPV within the last year, and one in three women (34.6%, 95% CI: 32.8%-36.5%) had experienced IPV during their lifetime. In 49 women (1.7%, 95% CI: 1.3%-2.2%), the clinic visit coinciding with questionnaire completion was a direct consequence of IPV. Of these women, only 7 (14.3%) had ever been asked about IPV within the health-care setting. Two-thirds of women believed orthopaedic surgeons were ideally positioned to ask about IPV during clinic visits.

Conclusion: PRAISE is the largest IPV screening study conducted to date in orthopaedics. Orthopaedic surgeons should be confident in the assumption that one in six women presenting to a fracture clinic have a previous history of physical abuse, and that one in 50 injured women will present as a direct result of IPV. Our findings warrant serious consideration for optimizing fracture clinics to identify, respond to, and provide referral services for IPV victims.

Δ OTA Grant

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Blowing Smoke: A Meta-Analysis of the Effects of Smoking on Fracture Healing and Postoperative Infection

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Purpose: Cigarette smoking is recognized as one of the major causes of preventable disease in the United States. However, there is little reported analysis regarding the effects of smoking on fracture healing and postoperative infection after long bone fractures. The aim of this study was to systematically review the association between smoking and fracture healing (nonunion and healing time) and infections.

Methods: MEDLINE, Embase, and Cochrane computerized literature databases and manual searches of bibliographies were performed. Randomized controlled trials and cohort studies (retrospective and prospective) evaluating the association between smoking and long bone fracture healing and smoking and infection were included. Descriptive and quantitative data were extracted. A meta-analysis was performed using a random effects model for nonunion, superficial, and deep infections in smoking and nonsmoking groups. Time to healing was evaluated using frequency-weighted means, and group-weighted standard deviations. Three sensitivity analyses were performed to evaluate the effects of tibia fractures, open fractures, and level of evidence. Study heterogeneity, criteria of methodological quality, and publication bias were also evaluated and adjusted for by using a trim and fill analysis.

Results: Initial search identified 7110 references. Of the 237 articles further inspected by title, 20 were included (7 prospective, and 13 retrospective cohort studies), and 18 offered sufficient data for meta-analysis. The adjusted odds of nonunion were 2.3 times in the smoking group compared to the nonsmoking group (95% confidence interval [CI]: 1.8, 3.0; $P < 0.01$). There was increased nonunion in smokers with tibia fractures (odds ratio [OR] 2.42; 95% CI: 1.7, 3.4; $P < 0.01$), and with open fractures only (2.42; 95% CI: 1.7, 3.4; $P < 0.01$). For all fracture types, the mean healing time was longer for smokers (30.2 weeks; 95% CI: 22.7, 37.7) than nonsmokers (24.1 weeks; 95% CI: 17.3, 30.9). For tibia fractures, the mean healing time was longer for smokers (32.0 weeks; 95% CI: 23.2, 41.0) than nonsmokers (25.1 weeks; 95% CI: 16.4, 33.9). There was no difference in postoperative superficial and deep infections between smokers and nonsmokers undergoing long bone fracture surgery ($P = 0.13$). Publication bias was noted in the small studies showing a larger effect size than larger studies. Trim and fill analysis was performed, which resulted in similar results to the original meta-analysis.

Conclusion: Smoking was associated with increased nonunion for all fractures, tibia fractures, and open fractures. Additionally, smokers trended toward longer mean healing times. The potential risks need to be discussed with all fracture patients, and smoking intervention programs instituted to promote better outcomes in postfracture patients.

See pages 91 - 132 for financial disclosure information.

Open Femoral Shaft Fractures: A Difficult Problem in Capable Hands

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Purpose: This study seeks to investigate the results of a large consecutive series of open femoral shaft fractures treated at a Level I trauma center by fellowship-trained surgeons using modern techniques.

Methods: Following IRB approval, adult patients sustaining an open femoral shaft fracture between 2008 and 2012 were identified from our institution's trauma database. Patients were followed for a minimum of 3 months or until death, radiographic union, or treatment failure. Patient demographics of age, gender, tobacco use, body mass index, and medical comorbidities were noted. Injury-related variables including the fracture mechanism, location, morphology, soft-tissue status, associated injuries, and ISS were also recorded. Finally, treatment-related factors including time to initial débridement, type of fixation, number of transfusions, and quality of reduction were assessed. The outcome measures of time until bony union, limb alignment, ambulatory status, the need for further surgical intervention, and complications such as nonunion and infection were tabulated and correlated with the previously mentioned independent variables.

Results: Between 2008 and 2012, 69 open femoral shaft fractures (OTA 32-A, B, and C) were treated at our Level I trauma center. 14 patients had inadequate follow-up, leaving 56 fractures available for this retrospective review with an average follow-up of 10 months. 41 fractures occurred in males, while 15 occurred in females. The average patient age was 36 years (range, 19-77). 39 patients had associated injuries and 16 fractures were isolated. The average ISS was 14.7 (range, 9-29). Two patients died during their initial hospitalization. The average time from presentation at our institution until the initial débridement was 11.4 hours. All fractures were treated with intramedullary nails; 46 were retrograde and 9 anterograde. 47 fractures (87%) achieved a bony union following their index definitive fixation procedure. The average time to union was 140 days. 8 fractures (15%) failed initial treatment, requiring a reoperation. Six of these were due to nonunion (5 aseptic, 1 septic) and 2 were due to acute postoperative infection. An additional 8 patients required secondary procedures including 3 symptomatic hardware removals, 2 quadricepsplasties, 2 knee manipulations, and 1 lengthening procedure. 10 patients required gait aids at their most recent follow-up.

Conclusion: Open femoral shaft fractures represent a significant challenge to the treating orthopaedic surgeon, are often incurred through high-energy mechanisms, and associated with other serious injuries. While closed femur fractures have a high reported union rate and low rate of reoperation for any reason, open femoral shaft fractures in this series demonstrated a reoperation rate of 30%, with 15% of patients failing initial treatment.

POSTER ABSTRACTS

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Obesity Is Associated With More Complications and Longer Hospital Stays After Orthopaedic Trauma

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Purpose: The incidence of obesity has escalated in recent years in the United States. Prior work has shown that obesity negatively impacts fracture imaging, reduction quality, and maintenance of fracture alignment. The purpose of this study is to characterize relationships between obesity and initial hospital stay, including complications, in patients with multiple system trauma and surgically treated fractures.

Methods: Review of 376 patients who had mechanically unstable, high-energy fractures of the femur, pelvic ring, acetabulum, or spine requiring surgical stabilization, and an associated major injury to another body system with an ISS greater than 16 was performed. Data for obese (body mass index [BMI] ≥30) versus nonobese (BMI <30) patients included presence of pneumonia, deep vein thrombosis (DVT), pulmonary embolism, infection, organ failure, and mortality. Days in ICU and hospital, days on ventilator, antibiotic dosage, transfusions, and surgical details were documented.

Results: 158 (42.0%) obese and 218 nonobese patients were studied. Females made up 29.8% of the overall study population but 38.0% of the obese population while only 23.9% of the nonobese population (P = 0.003). Mean BMI of all patients was 29.8, with a mean of 36.8 (range, 30.0-62.9) for obese patients and a mean of 24.7 (range, 16.4-29.9) for nonobese patients. 37 patients (9.84%) had BMI >40. Mean age of obese patients was 44.7 ± 16.2 years, while mean age of nonobese patients was 36.4 ± 16.5 (P <0.01). Mean ISS (28.1 vs 26.1, P = 0.12) and Glasgow coma score (13.7 vs 13.6, P = 0.75) were no different. Spine and acetabular fractures occurred with similar frequency, while obese patients were more likely to sustain pelvic fractures (23.4% vs 16.1%, P = 0.07) and nonobese patients had more femur fractures (38.0% vs 48.2%, P = 0.05). Injuries to head, chest, and abdomen occurred with equal frequency. Complications occurred more often in obese patients (38.0% vs 28.4%, P = 0.05), with more acute renal failure (5.70% vs 1.38%, P = 0.02) and infection (11.4% vs 5.50%, P = 0.04). Days in ICU and mechanical ventilation times were longer for obese patients (7.06 vs 5.25 days, P = 0.05; and 4.92 vs 2.90 days, P = 0.007, respectively). Mean total hospital stay was also significantly longer for obese patients (12.3 vs 9.79 days, P = 0.009). No significant differences in rates of mortality, multiple organ failure, or pulmonary complications were noted. Medically stable obese patients were almost twice as likely to experience delayed fracture fixation due to preference of the surgeon and were more likely to experience delay overall (26.0% vs 16.1%, P = 0.02). Mean time from injury to fixation was 34.9 hours in obese patients versus 23.7 hours in nonobese patients (P = 0.03).

Conclusion: Obesity is increasing over time and was frequent among our trauma patients. In obese patients complications occurred at slightly higher rates, and hospital and ICU stays were significantly longer, which are likely to be associated with greater hospital costs. Surgeon decision to delay procedures in medically stable obese patients may have contributed to these findings; definitive fixation was more likely to be delayed in obese patients. Further study to optimize the care of patients with increased BMI may help to improve outcomes and minimize additional treatment expenses.

See pages 91 - 132 for financial disclosure information.

Acute Blood Transfusion Is Associated With Pulmonary Complications in the Orthopaedic Trauma Patient

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Purpose: Blood products may be required to decrease mortality secondary to injury and associated massive hemorrhage. However, blood products are a known risk factor for infection and multiple organ failure, and controversy exists over the association of transfusions with in-hospital complications. The purpose of this project was to review the effect of limited acute blood product usage (1-3 units) on pulmonary complication rates and total hospital stay.

Methods: A retrospective review of a prospective database was performed. 371 consecutive patients with 419 fractures were identified between October 2010 and April 2013. All patients had ISS ≥16 and underwent fixation of high-energy, unstable fractures of the spine (n = 111), pelvis (n = 72), acetabulum (n = 57), and/or femur (n = 179). Patients who received greater than three units of packed red blood cells (PRBC) over the course of their hospital stay were excluded. Fracture type, associated injuries, American Society of Anesthesiologists (ASA) score, mechanical ventilation time, complications, and length of hospital stay were recorded. Details regarding surgical duration, procedures performed, laboratory values, and estimated blood loss (EBL) were also collected.

Results: 98 patients (26.4%) with 107 fractures, mean ISS of 23.9 (range, 16-59), and mean ASA score of 2.7 (range, 1-5) received a limited acute blood transfusion, defined as 1 to 3 units of PRBC throughout their hospital course. 119 patients (32.1%) with 123 fractures, mean ISS of 20.5 (range, 15-43), and mean ASA score of 2.3 (range, 1-4) did not receive any PRBC. The transfused and nontransfused groups did not differ significantly with respect to age (mean 39.0 vs 36.4), fracture type, mean number of hours from injury to fracture fixation (mean 25.0 vs 22.0), or presence of associated injuries, including any minor (AIS [abbreviated injury scale] ≤2) or major (AIS ≥3) head, chest, or abdominal trauma. Specifically, chest injury was present in 53% of patients in the transfused group versus 45% of the nontransfused group (P = 0.21). The initial hematocrit (Hct) value recorded after patient admission was lower in the transfused group (mean 37.3 vs 40.8, P <0.0001). Similarly, the lowest Hct value over the entire patient hospital course was also lower in the transfused group (mean 22.8 vs 30.0, P <0.0001). Surgical duration (mean hours of 3:23 vs 2:28, P <0.0001), number of procedures performed in the same surgical setting (mean of 1.44 vs 1.21, P <0.0001), and EBL (mean of 462 cc vs 211 cc, P = 0.003) were all significantly higher in the transfused group. Pulmonary complications were identified in 12% of the transfused group and 4% of the nontransfused group (P = 0.028), with 10% (vs 2%) of the transfused patients developing pneumonia (P = 0.0063). For patients who received 1 to 3 units of PRBC, average total days with mechanical ventilator assistance were 2.51 versus 0.45 in patients who were not transfused (P = 0.001). Mean total hospital stay was 8.8 days versus 5.7 days (P <0.0001), respectively.

Conclusion: Blood products are administered acutely to maintain oxygen delivery and to correct acidosis in patients with severe hemorrhage associated with injury. Massive transfusions prevent exsanguination. However, smaller amounts of transfused products were

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associated with pulmonary complications and longer mechanical ventilation and hospital times. The indications for transfusion in this group deserve further study. Clearly, the lower Hct, in addition to a greater surgical burden and subsequent blood loss, in the transfused group prompted transfusion and it is unknown whether other complications such as cardiac demise, deficient healing, or even inability to tolerate sitting or transfer from bed would ensue in the event these patients were not transfused. Further study of blood product usage in trauma patients may provide more insight into the effects of transfusions on overall patient outcome.

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Muscle Viability Revisited: Are We Removing Normal Muscle?
A Critical Evaluation of Dogmatic Débridement

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Background/Purpose: Surgeon determination of muscle viability during débridement is an egregiously subjective process with potentially significant long-term functional consequences. The foundation for our current practice of grossly evaluating muscle color, consistency, contractility, and capacity to bleed (the 4 Cs) was established based on the results of a rudimentary histopathologic study performed half a century ago. This work attempts to investigate these historical results using current histopathologic techniques.

Methods: Following IRB approval, 36 muscle biopsies were prospectively collected at a Level I trauma center by 4 fellowship-trained traumatologists from 20 patients undergoing a débridement for open fracture (81%), compartment syndrome (11%), infection (5%), or soft-tissue injury (3%). The biopsies were obtained from the leg (56%), forearm (19%), arm (11%), ankle (8%), and thigh (6%). The treating surgeon graded the biopsies using the 4 Cs and provided their impression of the overall viability of the biopsied muscle, rating it as healthy, borderline, or dead. Blinded pathologic analysis was performed on each biopsy specimen. Frozen-section and paraffin-embedded histologic preparations were evaluated microscopically to determine the presence of edema, interstitial inflammation, myositis, and necrosis. Muscle fiber viability was determined using hematoxylin and eosin staining. Loss of normal cytologic architecture and fiber typing were assessed using trichrome and NADH staining, respectively. A correlation between surgeon impression and histopathologic diagnosis was sought.

Results: The surgeon's impression was dead muscle in 25 specimens, borderline in 10, and healthy in 1. Grading of muscle color yielded 20 purple, 10 brown, and 6 pink specimens. 33 specimens were noted to be noncontractile, while 3 were contractile. 29 specimens demonstrated a friable consistency; the remaining 7 were firm. 28 specimens did not exhibit a capacity to bleed, while the remaining 8 did. Pathologic analysis of the 25 specimens considered dead muscle by the surgeon demonstrated normal muscle or mild interstitial inflammation in 14 specimens, moderate degenerative changes in 3, and varying degrees of necrosis in 8. Of the 10 specimens deemed borderline by the surgeon, 7 demonstrated normal muscle or mild interstitial inflammation, 2 demonstrated moderate degenerative changes, and 1 demonstrated necrosis. The single specimen thought to be healthy muscle by the treating surgeon was noted to have moderate degenerative changes on pathologic assessment.

Conclusion: In the setting of acute trauma, a correlation between gross evaluation of the 4Cs and histopathologic appearance remains unsubstantiated. In 72% of specimens the treating surgeon's gross assessment differed from the histopathologic findings. Although

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the fate of the débrided muscle remains unclear if left in situ, these results raise important questions regarding current practices, including the possibility that experienced surgeons are débriding potentially viable muscle. A more objective means of assessing muscle viability should be investigated.

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Osseointegration as a Viable Treatment Option for Rehabilitation of Amputees

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Background/Purpose: Transcutaneous osseointegration is an innovative technology that has been successfully used for amputees since the 1990s to overcome the problems associated with the conventional socket prosthesis. Between 1999 and 2011 we performed 100 operations using this technology; 76% of these patients were amputated due to trauma. We are presenting our results.

Methods: Between 1999 and 2011 we performed 100 osseointegration procedures in 94 patients. These surgeries were performed in two centers: Lübeck, Germany and Sydney, Australia by the two principal surgeons acquainted with this technology. It involves the insertion of a transcutaneous intramedullary implant into the remaining bone; the implant's most distal external aspect then serves as a hard point for further prosthetic attachment rather than the entire soft tissue mantle of the remaining limb. Altogether there were 74 males and 20 females. The age range was between 2 and 76 years at time of amputation and 17 to 76 years at time of implantation. 71 of our patients had amputations due to traumatic accidents with an age range from 4 to 60 years at time of amputation and 17 to 69 years at time of implantation. Preoperative assessments included medical, psychological, and radiological examinations. All patients underwent the standardized two-stage procedure with a 6-week interval. All patients were allowed early mobilization and full weight bearing 2 weeks after the second-stage surgery.

Results: Overall, there was a high level of patient satisfaction. Most patients returned to preamputation activities. Three of the implants had to be explanted, but two could be reimplanted. The other patients have retained the implant up-to-date and their gait improved. No infections to date occurred in the patients who underwent surgery after 2009 since a new implant design was used. All patients regained osseoperception and reduced phantom pain. Skin irritations due to the old socket prosthesis have completely recovered in all patients.

Conclusion: Osseointegrated prostheses are an excellent alternative and potentially will be the first choice for many amputees in the near future. We have demonstrated that this technology enables patients to regain much of their freedom in mobility without compromising the mechanical stability of osseointegration. The technique constitutes a versatile option for people suffering limb loss secondary to trauma due to the often young age of these patients at time of amputation. We believe that osseointegration provides a great opportunity to regain an active lifestyle and participate in daily routines almost like an able-bodied person.

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Split-Thickness Skin Grafts for Residual Limb Coverage and Preservation of Amputation Length

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Background/Purpose: Due to concerns regarding durability and complication rates, split-thickness skin grafts (STSG) have historically been used sparingly for amputation coverage when primary closure is not feasible without substantial loss of length. We hypothesized that amputations with STSG would be associated with an increased rate of wound complications and reoperations as well as an increased rate of heterotopic ossification (HO) requiring excision versus residual limbs that were closed primarily with either conventional or atypical fasciocutaneous flaps. We further hypothesized that although the complication rate may be higher in skin-grafted residual limbs, the STSG would ultimately facilitate length and level preservation as anticipated.

Methods: We performed a retrospective review of 300 consecutive lower extremity and 100 consecutive upper extremity amputations treated at our facility from 2005 on and 2003 to 2009 respectively comparing patients treated with STSG (study cohort) to those treated with delayed primary closure (DPC, controls). Principal outcomes measured included early (wound failure) and late (HO requiring excision and soft-tissue revisions) complications requiring operative treatment.

Results: Statistically significant differences were seen with the STSG group having an increased incidence of wound failure ($P<0.022$), HO requiring excision ($P<0.001$), and soft-tissue revisions ($P<0.001$) as compared to controls. The risks of revision were higher for lower than upper extremity amputations undergoing STSG. However, amputation level salvage was successful for all residual limbs with STSG.

Conclusion: STSG for closure of amputations results in significantly increased reoperation rates, but is ultimately successful in salvaging residual limb length and amputation levels. STSG in carefully selected patients may be a successful means of achieving definitive coverage when performed over robust, healthy muscle. In many patients, however, STSG should be viewed as a staging procedure in order to maintain length and amputation level until swelling decreases and revision surgery for STSG excision with or without concurrent procedures can be performed without the need to substantially shorten the residual limb.

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Retrograde Nailing of Distal Femur Periprosthetic Fractures: Malunion by Design?

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Background/Purpose: Retrograde femoral nailing (RFN) is commonly performed after periprosthetic distal femur fracture. Most previous studies have focused on whether the distal femoral prosthesis has a closed or open box design, as well as the size and shape of the box. No studies to date have evaluated the box position or notch depth in the sagittal plane. Our clinical experience has been that modern femoral components with deeper trochlear grooves posteriorly displace the nail, resulting in a recurvatum deformity. This study was performed to evaluate how the starting point in RFN is affected by distal femoral prosthetic design.

Methods: From our library of surgeon-directed perfect lateral radiographs, 113 images were selected. Blumensaat's line was chosen as the most posterior starting point acceptable for retrograde femoral nail placement. The location of Blumensaat's line was determined as a ratio of the distal femur size (starting point ratio [SPR]) in the sagittal plane along a line perpendicular to the anterior femoral cortex (Figure 1). Additionally, implants from six orthopaedic companies were analyzed to examine the location of the box or notch using the trial components in a range of sizes. Only trials that are the same size as real implants were analyzed. A 12-mm rod was placed in a maximally anterior position to mimic nail position. Measurements were taken to determine the position of the plug in the sagittal plane. The plug position was determined as a ratio of the AP size of the femoral component (component ratio) (Figure 2).

Results: 113 perfect lateral radiographs included 60 men and 53 women, with an average age of 47 years (range, 17-100). The average starting point ratio was 0.394 ± 0.03. The entire sample group of cruciate-retaining (CR) and posteriorly stabilized (PS) components had a component ratio of 0.416 ± 0.05. All implants accommodated the 12-mm rod. The CR implants had an aggregate component ratio of 0.444 ± 0.06, while the PS prostheses had a component ratio of 0.393 ± 0.04. With respect to each design, the CR implants had a larger component ratio (more posterior starting point) than the PS implants. Within each design, the component ratio had substantial variability based on implant size. In some cases, the larger implant had a greater component ratio (more posterior starting point). In other instances, the larger implant had a lower component ratio (more anterior starting point).

Conclusion: Our study showed significant variability in the component ratio that is dependent on manufacturer and implant design. Although some implants accommodated a starting point at or anterior to Blumensaat's line, 40 of 68 implants necessitated a starting point posterior to Blumensaat's line, increasing the risk for recurvatum deformity with retrograde nailing. The posterior starting point was particularly pronounced with more recent CR implant designs. This information is important when deciding to nail or plate a distal femur periprosthetic fracture.

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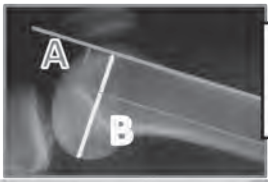

Figure 1. Starting Point Ratio = A/B

Figure 2. Component Ratio = X/Y

Table 1. Implant	Avg. Component Ratio	Std. Dev.
Biomet Vanguard CR	0.439	±0.025
Biomet Vanguard PS	0.365	±0.017
DePuy Attune CR	0.455	±0.008
DePuy Attune PS	0.389	±0.018
Exactech Optetrak Cr	0.407	±0.044
Exactech Optetrak Logic PS	0.402	±0.012
Smith & Nephew Gen II PSC	0.409	±0.014
Stryker Triathlon CR	0.390	±0.013
Stryker Triathlon PS	0.363	±0.011
Zimmer Nexgen CR	0.560	±0.009
Zimmer Nexgen LPS	0.450	±0.051

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Initial Injury Severity and Social Factors Determine Ability to Redeploy After Amputation

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Background/Purpose: Combat-related amputees require significant treatment and rehabilitation resources in an effort to optimize their function and outcome after their injury. Few outcomes signify such recovery better than the ability to be redeployed to a combat zone but it remains unknown how many amputees attain this fate. We hypothesized that less than 10% of all amputees would be redeployed.

Methods: All U.S. servicemembers who sustained major extremity amputations from September 2001 through July 2011 were analyzed. Amputation level(s), mechanism of injury, time interval to amputation, age, rank Physical Evaluation Board (PEB) disposition outcome, and ability to redeploy after amputation were determined.

Results: Of the 1221 amputees, deployment information after amputation was obtained for 953 (78%), 47 (5%) of whom were able to redeploy after their amputation. There were no significant differences among service branches for the redeployment of amputees (all P values >0.2). Amputees found fit for duty (20) or continued on active duty (COAD) (47) were significantly (P <0.0001) more likely to be redeployed than amputees not found fit for duty. Amputees who did not have their amputation on the day of injury (176, 18%) were significantly more likely ($P = 0.0106$) to be redeployed than amputees who underwent their amputation on the day of injury but no significance was found between late amputees (106, 11%) (amputees who underwent an amputation >90 days after injury) and redeployment ($P = 0.0912$). Officers were significantly (P <0.0001) more likely to be redeployed and junior enlisted servicemembers were significantly more likely to not be redeployed (P <0.0001). Redeployed amputees had a significantly ($P = 0.0017$) lower mean ISS (16.0, standard error of the mean [SEM] 1.23) and combined disability rating (66.3) than those amputees who were not redeployed (20.9, SEM 0.31 and 75.5, respectively). The amputation locations for both the redeployed and the nonredeployed amputees are seen on the next page.

Conclusion: The vast majority of amputees are not able to deploy after undergoing their amputation. Those amputees who are able to redeploy are typically less severely injured and of higher rank than the nonredeployed amputees. This study may add further support to the theory that many of the most important factors that influence outcome after severe lower extremity trauma may be largely patient-centered and out of the control of the treating surgeon. Further evaluation of the surgical factors that relate to the best outcomes of these amputees is ongoing.

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Amputation Location	Redeployed	%	Not Redeployed	%	*P* Value
Transhumeral	1	2%	45	5%	0.7223
Transfemoral	9	19%	163	18%	0.8459
Transfemoral, transtibial	1	2%	37	4%	1
Transradial	3	6%	57	6%	1
Transtibial, Transtibial	2	4%	52	6%	1
Transtibial	27	57%	324	36%	0.0047
Transtibial, knee disarticulation	1	2%	13	1%	0.5099
Ankle disarticulation	1	2%	20	2%	1
Wrist disarticulation	2	4%	22	2%	0.3337
Multiple limb amputation	4	9%	362	40%	<.0001

POSTER ABSTRACTS

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Shock as a Risk Factor for Posttraumatic Stress Disorder Symptoms in Spine Trauma

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Purpose: Posttraumatic Stress Disorder (PTSD) can cause substantial difficulty with social, occupational, or other functioning. This study evaluated vital signs obtained at hospital presentation and ISS with the risk of developing PTSD symptoms at greater than 6 weeks after traumatic spine injury.

Methods: Our patient sample was 86 adult spine trauma patients admitted at a Level I trauma center from October 2009 to September 2012 with a minimum follow-up of 6 months. Initial physiologic measures (systolic and diastolic blood pressure, mean arterial pressure [MAP], heart and respiratory rate) were abstracted from medical records. We defined shock as systolic blood pressure (SBP) less than 90 mm Hg. ISS was obtained from the institution's trauma registry. PTSD-associated symptoms were prospectively assessed using two validated measures: PTSD Check List – Civilian (PCL-C) and Impact of Events Scale-Revised (IES-R). A PCL-C score of ≥35 or IES-R score of ≥27 at either 6 weeks or 6 months was used to define PTSD symptoms. *T* tests and χ^2 tests were used to analyze data.

Results: The prevalence of PTSD symptoms was 53% (46 of 86). Shock was inversely associated with PTSD; 100% of patients with a SBP ≤90 mm Hg had PTSD symptoms compared to 49% of patients with SBP >90 mm Hg (P <0.01). Patients with relative hypotension (MAP ≤90 mm Hg) had similar prevalence (83% and 24%, respectively, P <0.001). Patients with PTSD symptoms had mean SBP, MAP, and diastolic blood pressure (DBP) on average 20 mm Hg lower than those without symptoms (P <0.01 for all). PTSD symptom prevalence was also associated with lower MAP and SBP when grouped into quartiles (see figure, P <0.01 for both). We were unable to determine a relation between DBP, ISS, heart or respiratory rate, and PTSD symptoms. The relationship between MAP and SBP with PTSD was maintained after stratifying by ISS above and below the median.

Conclusion: The prevalence of PTSD symptoms is associated with low mean arterial blood pressure and SBP at hospital admission, independent of injury severity.

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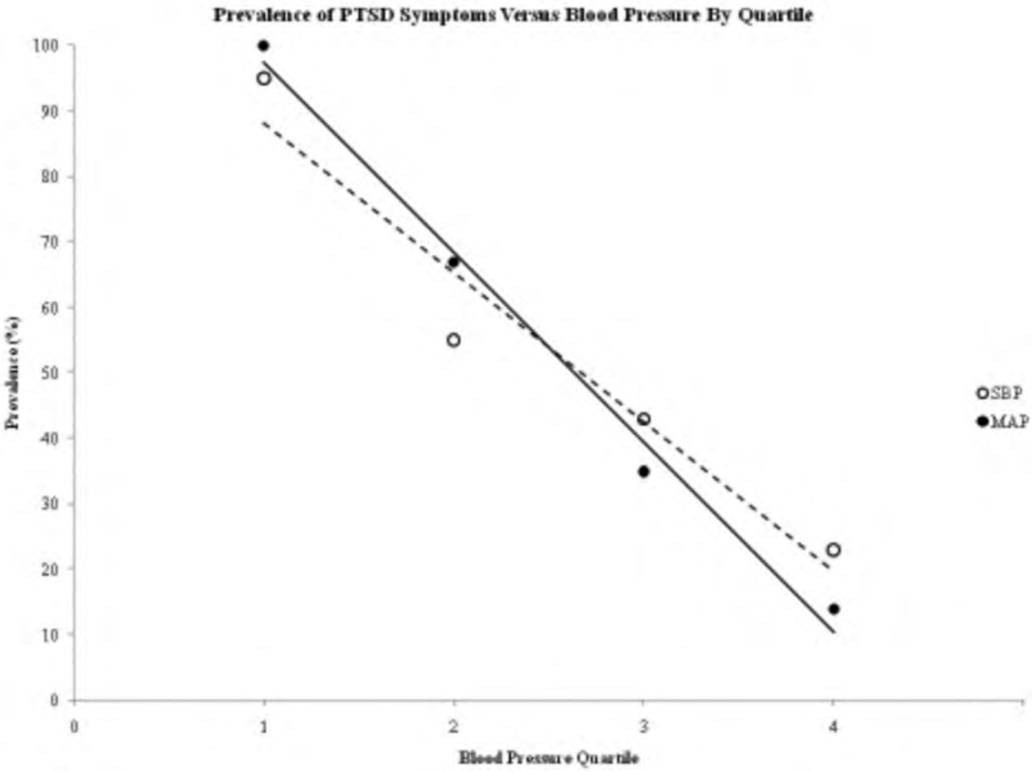

POSTER ABSTRACTS

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Do Residents Know Evidence-Based Guidelines for Cervical Spine Clearance in Blunt Trauma Patients?

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Purpose: This study was designed to investigate resident knowledge of cervical spine clearance in adult blunt trauma patients at an academic Level I trauma center. The hypothesis was that most residents would be able to apply an evidence based algorithm to clear the cervical spine (C-spine) when presented with case-based scenarios and that there would not be a knowledge difference among residents in different specialties.

Methods: Residents in the departments of Orthopaedic Surgery, Neurosurgery, General Surgery, and Emergency Medicine at a single academic institution who rotate through a Level I trauma center were e-mailed a survey investigating their knowledge of current evidence-based C-spine clearance protocols.

Results: The response rate was 76%. 97% used an appropriate hard collar for temporary immobilization of the C-spine. 83% of the residents use an acceptable clinical clearance guideline (NEXUS or Canadian C-Spine Rules) when deciding which patients need imaging studies. 57% of residents are aware of the existence of an official C-spine clearance protocol at their institution. For patients who need radiographic imaging, 70% preferred CT as the first line of imaging. In patients with neck pain following a negative CT scan, 85% correctly managed the patient by keeping the hard collar on, ordering MRI, or obtaining flexion-extension views in the emergency department. For obtunded patients, 97% correctly managed the patient by keeping the hard collar on until a reliable examination could be obtained, clearing the C-spine based on the CT only and transitioning the patient into a soft collar, or ordering cervical MRI. The percentage of residents by specialty who properly managed each clinical case can be found in Table 1.

Table 1: Percentage of residents by department who selected an appropriate answer for clinical scenarios.

Department	Clinical Clearance	Imaging	Patient With Neck Pain	Obtunded Patient
Orthopaedics	100	70	100	100
Neurosurgery	60	73	87	100
Emerg Med	94	66	71	86
Gen Surg	78	72	81	100
Average	83	70	85	97

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Conclusion: The majority of residents have adequate knowledge of evidence-based C-spine clearance protocols. However, one-third of the residents who take trauma call at a Level I trauma center are still unaware of appropriate first-line imaging of the C-spine in a blunt trauma patient. Residents also do not uniformly apply guidelines in order to determine which patients need imaging studies. In addition, there is a difference in knowledge levels among residents in various departments in the management of patients with neck pain following a negative CT scan, and the management of obtunded patients with negative CT scans. Despite the presence of an official C-spine clearance protocol at this institution, knowledge of it does not appear to be widespread. There is significant room for improvement in resident education with regard to evidence-based guidelines for C-spine clearance.

See pages 91 - 132 for financial disclosure information.

The Retrograde Tibial Nail: A New Implant Concept for Distal Tibia Fractures

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Background/Purpose: The surgical treatment of distal tibial fractures demands a stable fixation while minimizing the irritation to the soft tissues by the surgical approach and implants. The Retrograde Tibial Nail (RTN) is a prototype intramedullary implant developed by our group. It offers double proximal and triple distal interlocking with an end cap leading to an angle-stable screw-nail construct. The aim of this study was to investigate the usability of the nail in different distal tibial fracture types and to evaluate the biomechanical properties of the bone-implant construct.

Methods: Implantation studies with the RTN were conducted in human cadaveric lower leg specimens. The RTN was implanted in different extra-articular and simple intra-articular distal tibial fractures. Primary alignment, soft-tissue protection, and complications during implantation were the outcome measures. The biomechanical evaluation compared the RTN against antegrade nailing (Expert Tibial Nail [ETN], Synthes) both with double proximal and triple distal interlocking. Seven biomechanical composite tibiae were treated with either osteosynthesis technique. A 10-mm defect osteotomy 40 mm proximal to the joint line served as an AO/OTA 43-A3 type fracture model. The stiffness of the implant-bone constructs was measured under low and high axial compression (350 and 600 N) and under torsional load (8 Nm).

Results: The implantation study allowed for a safe and minimally invasive use of the RTN as a sole implant in 43-A1/A2/A3 fractures. In combination with primary lag screw fixation of the articular block, the RTN was also successfully implanted in 43-C1 type fractures. The biomechanical results show a comparable stability of antegrade and retrograde intramedullary nailing during the low (ETN 844 N/mm vs RTN 911 N/mm) and high (ETN 797 N/mm vs RTN 928 N/mm) axial loading tests. Rotational stability testing resulted in superior performance for the RTN (ETN 0.66 Nm/deg vs RTN 1.90 Nm/deg). Statistical analysis proved a significant difference between the ETN and RTN for rotational stability.

Conclusion: The experimental Retrograde Tibial Nail meets the requirements of a minimally invasive surgical approach, with the ability of a secure fracture fixation. The outcome of this study suggests the RTN to be a promising new concept for the treatment of distal tibial fractures.

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Infection Rates Following Intramedullary Nailing of Open Tibial Shaft Fractures in Low- and Middle-Income Countries

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Background/Purpose: The Surgical Implant Generation Network (SIGN) provides intramedullary nails at no cost to hospitals in low- and middle-income countries. In return, surgeons are required to record clinical and radiographic data in the SIGN Online Surgical Database (SOSD). To date, more than 100,000 SIGN nails have been implanted worldwide to treat long bone fractures, and the SOSD contains data for more than 55,000 of these cases. The SOSD has been validated previously; it was shown to reliably report rates of infection as long as follow-up exceeded a minimum threshold of 5%. The purpose of the current study was to determine the rates of infection in over 6000 open tibial shaft fractures treated with the SIGN intramedullary nail in low- and middle-income countries.

Methods: All patients in low- and middle-income countries with open tibial shaft fractures treated with the SIGN intramedullary nail and entered into the SOSD from the establishment of the database in March 2000 through February 1, 2013 were analyzed. Rates of follow-up were recorded for this cohort and compared with overall SIGN nail follow-up rates. Rates of infection (superficial or deep) were determined for each Gustilo and Anderson fracture type. Rates of union were calculated in patients who developed infection and those who did not.

Results: Over the study period, 55,743 SIGN nails were implanted in low- and middle-income countries and recorded in the SOSD. 27.07% of fractures were seen at least once in follow-up. We identified 6110 open tibia fractures. The overall infection rate was 3.39%. Rates of infection by Gustilo and Anderson fracture type were 1.76% for Type I, 3.49% for Type II, 4.69% for Type IIIa, 7.41% for Type IIIb, and 11.54% for Type IIIc. 1656 of the patients with open tibia fractures (27.10%) returned for at least one postoperative follow-up visit. If only patients with a registered follow-up visit were included, the overall rate of infection was 12.5%, and infection rates by Gustilo and Anderson fracture type were 6.97% for Type I, 13.21% for Type II, 15.63% for Type IIIa, 23.62% for Type IIIb, and 27.27% for Type IIIc. Radiographic union at final follow-up was seen in 79.2% of patients who developed infection and 85.6% of those who did not.

Conclusion: Open tibia fractures can be treated effectively with the SIGN intramedullary nail in low- and middle-income countries with an overall rate of infection between 3.39% and 12.5%. Not surprisingly, overall infection rates following intramedullary nailing of open tibial shaft fractures were higher than the previously reported rate of 0.7% for all SIGN nails in the database. Due to financial and geographic barriers common to patients in the developing world, many patients do not return for routine follow-up visits unless they are symptomatic. The true infection rate, therefore, is likely lower than 12.5%.

See pages 91 - 132 for financial disclosure information.

Distal Tibia Fractures and Medial Plating: Factors Influencing Reoperation

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Background/Purpose: Medial plating of extra-articular distal tibia fractures remains a viable option for treatment. Many authors have demonstrated good union rates and low complication rates in patients undergoing medial plating of distal tibia fractures with both locking (L) and nonlocking (NL) implants. However, these retrospective studies have demonstrated smaller numbers of patients. Furthermore, they have not explored the overall complication rates based on open or closed injury, as well as potential differences in utilization of L and NL implants. Such a comparison is critical given the vast difference in cost between L and NL plates (approximately 8-10 times greater in L constructs). In the largest retrospective review to date of patients undergoing medial plating of extra-articular distal tibia fractures, this study seeks to describe the overall complications requiring reoperation in patients undergoing medial open reduction and internal fixation [ORIF] of distal tibia fractures at a single Level I trauma center. Baseline reoperation risks are important in understanding a future health-care system that may penalize early reoperations.

Methods: IRB clearance was obtained. All patients (n = 398) who sustained a distal tibial shaft fracture and were treated with ORIF between January 1, 2002 and January 30, 2012 were identified through a search of the institution's orthopaedic trauma database using CPT and ICD-9 code information. Radiographs, charts, and operative notes of each patient were then retrospectively reviewed to determine type of fracture (open vs closed), if a medial plate was used, and if the implant was L or NL. Any case in which a medial plate was not used or a medial plate was used along with another tibial plate (ie, anterolateral plate or posterolateral plate) was excluded. Each chart was also reviewed to determine if any complications leading to reoperations occurred. Complications were categorized into five groups including hardware pain/prominence, wound healing issues, infection, nonunion, and malunion.

Results: 96 patients were identified with distal tibia fractures treated with a medial plate. 60 patients (62.5%) had closed distal tibia fractures, while the remaining 36 were open injuries. The overall complication rate leading to reoperation in all patients was 35% (n = 34 patients). Evaluating complication/reoperation rates in the closed and open medial plate group, there was a large difference between groups, 28% (n = 17) in the closed group as compared to 47% (n = 17) in the open group. Using the categories of complication for subanalysis, there was a significant difference ($P = 0.009$) in nonunions between the closed (n = 5, 8.1%) and open groups (n = 11, 30.6%). There was also a significant difference ($P = 0.005$) when evaluating hardware pain/prominence requiring reoperation between the closed group (n = 8, 41.7%) and the open group (n = 2, 11.8%). There was no significant relationship between use of an L or NL plate and complications in either the open (27 L, 9 NL) or closed tibia group (38 L, 22 NL).

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Conclusion: This study demonstrates a very high reoperation rate for the treatment of distal tibia fractures with medial plates that is not influenced by the use of L or NL plates. Patients should be counseled on the high risk of reoperation. A notable difference is seen in complications between open and closed fracture, which appears to be driven by the high rate of nonunion in the open group. Reoperations in the closed group are driven by hardware pain/prominence. In the open group, this study implies the potential need for early bone grafting or use of an alternate implant.

See pages 91 - 132 for financial disclosure information.

Does the New OTA Classification for Open Fractures Predict the Risk of Lower Limb Amputation?

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Background/Purpose: The Gustilo and Anderson classification for open fractures is the most widely used despite criticism of its interobserver variability, reproducibility, and poor correlation with treatment. The Classification Committee of the OTA recently proposed a new classification scheme, which is not widely used partly due to the paucity of studies. Our study aims to assess the validity of the new OTA classification at predicting the need for lower limb amputation in open fractures. Our null hypothesis is that there is no statistically significant difference in the OTA classification score between patients who required an amputation and patients in which limb salvage was successful.

Methods: IRB approval was granted. We used our fracture database to identify all adult patients admitted at our Level I trauma center between January 2012 and December 2012 with a diagnosis of open fracture. We reviewed patients' charts, operative reports, and radiographs to retrospectively classify their injury at the time of the first incision and débridement procedure with skin injury status, muscle damage, arterial injury, contamination, and bone loss graded 1, 2, 3 based on the severity of injury. Patient outcomes were recorded as either amputation or limb salvage. The OTA classification scores between limb salvage and amputated patients were analyzed using nonparametric univariate statistical tests.

Results: 172 patients were identified. 45 patients were excluded for unclear and incomplete operative reports. 127 patients (117 limb salvage and 10 amputation) were available to review with a mean follow-up of 23 weeks (range, 12-125). The mean OTA open fracture score was 7.9 ± 4.2 (range, 5-15) with a mean of 12.3 ± 3.8 in the amputated group versus 6.3 ± 1.3 in the limb salvaged group. The difference between these 2 groups was statistically significant (P <0.01).

Conclusion: Our study suggests that the new OTA classification for open fractures can guide treatment and predict outcome. It seems to be a sensitive tool with higher scores associated with higher risk of lower limb amputation.

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Semi-Elective Treatment of Open Tibial Shaft Fractures With Intramedullary Nail Fixation and Primary Wound Closure: Is it Safe?

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Background/Purpose: Dogma-driven treatment of open fractures with emergent operative débridement within a 6-hour time window has recently been challenged. It has been our policy to avoid overnight procedures to reduce resource utilization and preferentially operate with dedicated orthopaedic surgical teams. Open fractures that are admitted during nighttime hours are typically brought to the operating room as a first case the following day in a semi-elective fashion. This delay in surgical treatment poses two questions. First and foremost, does a delay in treatment increase the incidence of deep infection? And second, is it safe to close these potentially colonized wounds primarily?

Methods: Following IRB approval, patients presenting to our Level I trauma center between 2009 and 2012 who underwent treatment for an open tibial shaft fractures (OTA 42) where surgery was intentionally delayed at least 6 hours following their injury were retrospectively reviewed. Treatment for all patients included irrigation and débridement, placement of an intramedullary nail, and primary wound closure. All patients received provisional wound irrigation and intravenous antibiotics in the emergency department. Tetanus vaccination status was also verified. Patients who required spanning fixation, fasciotomies, vacuum-assisted closure, or flap coverage were excluded from our analysis. Patients were followed until death, reoperation, or a minimum of 3 months. The mean clinical follow-up was 10 months (range, 3-29 months). Patient age, gender, tobacco use, and medical comorbidities were noted. The mechanism of injury and Gustilo classification grade were determined. Time from injury until the first dose of antibiotics and operative treatment were also recorded.

Results: Between 2009 and 2012, 40 open tibia fractures occurring in 39 patients, with a mean age of 41 years, met our inclusion criteria and were treated using the aforementioned protocol. 12 fractures were classified as Gustilo type 1 injuries, 15 as type 2, and 13 as type 3A. The average time from the injury until the first dose of antibiotics was 112 minutes (range, 36-458). The average time from the injury until operative treatment was 13 hours (range, 6-38). Following treatment, 4 deep infections occurred (10%). Of these, none occurred in Gustilo type 1 injuries, 1 occurred in Gustilo 2 injuries, and 3 in Gustilo 3A injuries. Thus, the infection rate for Gustilo type 1 injuries was 0%, the infection rate for Gustilo type 2 injuries was 8%, and the infection rate for Gustilo type 3A was 23%.

Conclusion: This study challenges the dogma that open tibia fractures require urgent débridement within 6 hours and that primary closure after this window has elapsed is contraindicated. Treatment with a semi-elective protocol and immediate closure did not appear to increase the risk of infection when compared to historical controls treated on an emergent basis.

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Regional Block Anesthesia Improves Outcome in Patients Undergoing Proximal Humerus Fracture Repair Compared to General Anesthesia

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Background/Purpose: Recent literature has focused on the use of regional anesthesia for repair of traumatic fracture. These studies have demonstrated the benefits of this approach with respect to clinical and functional outcomes. The purpose of this study was to examine the functional outcome following open reduction and internal fixation of a displaced proximal humerus fracture in patients who received a brachial plexus block compared to those who had general anesthesia for their surgery.

Methods: 92 patients who had sustained 93 proximal humeral fractures were grouped according to anesthesia type: regional interscalene brachial plexus block, with or without general anesthesia, or general anesthesia alone for the surgical repair. Patients were asked to complete the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire and range of motion assessments at a minimum 6-month clinical follow-up.

Results: 45 patients (48.9%) with 45 proximal humerus fractures received a regional anesthetic, while the remaining 47 patients (51.1%) with 48 proximal humerus fractures had undergone general anesthesia at the time of definitive fixation. No significant differences existed between the two groups. DASH scores at the most recent follow-up interval were found to be significantly better in the group that had received regional block (38.6) compared to the general anesthesia group (53.1) ($P = 0.003$). The regional block group had significantly better range of motion in all categories except internal rotation ($P = 0.002$, 0.005, 0.002, and 0.507, respectively).

Conclusion: Patients who received a brachial plexus interscalene block were found to have better functional outcome and range of motion at the most recent clinical follow-up. Regional anesthesia provides patients with prolonged postoperative pain relief, which may allow for early mobilization, increasing the likelihood that the patient's function and range of motion will return to baseline.

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Factors Influencing Infection Rates After Open Fractures of the Forearm

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Purpose: Factors influencing infection rates after open fractures of the lower extremity have been extensively studied in the orthopaedic literature; however, few studies have focused solely on open fractures of the upper extremity and their potential to develop infection. The purpose of this study is to determine which factors influence the rates of infection following open fractures of the forearm (AO/OTA Type 21, 22, and 23 fractures).

Methods: 297 open fractures of the radius and/or ulna were retrospectively reviewed. Of these patients, 201 had at least 6-month follow-up and were included in this study. The following variables were examined for each patient: time from injury to antibiotic administration, time from injury to operative débridement, Gustilo-Anderson classification, type of antibiotic received, and host characteristics such as age, diabetes, and tobacco use. Outcome parameters included the presence of deep infection and fracture union. Statistical analysis was performed using Fisher's exact test, χ^2 test, and bivariate logistic regression analysis.

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Results: Based on the Gustilo-Anderson classification, 71 (23.9%) of the injuries were type 1, 69 (23.2%) were type 2, and 117 (39.4%) were type 3 injuries. Of the 201 patients who had at least 6-month follow-up, the overall rate of deep infection was 5.5% (11 of 201) and the rate of nonunion was 15.3% (26 of 170). No type 1 fractures (0 of 41) developed deep infection. In contrast, 4.3% (2 of 48) of type 2 and 8.3% (9 of 108) of type 3 fractures developed infection. 6.3% (2 of 32) of type 1, 10.3% (4 of 39) of type 2, and 22.2% (22 of 99) of type 3 fractures went on to nonunion. In bivariate analysis, type 3 fractures were 3.9 times more likely to develop infection than type 1 and 2 combined ($P = 0.09$) and 3.1 times more likely to develop nonunion ($P = 0.02$). 28 patients both received antibiotics in under 3 hours and underwent débridement in less than 6 hours from time of injury; however, they did not have a lower risk of either infection ($P = 0.39$) or nonunion ($P = 0.36$, $n = 24$) than those who either received antibiotics or débridement after those time frames.

Conclusion: Factors such as time to antibiotics and time to operative débridement were not associated with the rate of development of either deep infection or nonunion in open fractures of the radius and/or ulna. Receiving antibiotics within 3 hours and/or undergoing operative débridement within 6 hours were not associated with lower rates of deep infection or of nonunion. The "type" of fracture as outlined by the Gustilo-Anderson classification was the factor most substantially associated with the development of deep infection and nonunion of open fractures of the radius and/or ulna.

See pages 91 - 132 for financial disclosure information.

Does Outcome Justify Cost? A Comparison of Locked Plates and Nonlocked Plates for the Treatment of Simple Olecranon Fractures

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Purpose: The purpose of this study was to compare the clinical and functional outcomes, as well as total cost, in a cohort of patients treated for a simple olecranon fracture. Our null hypothesis was that no advantage would be identified in patients treated with a precontoured locking plate (LP) compared to those treated with a nonlocking "hook" plate (HP).

Methods: We performed a retrospective review of operatively treated olecranon fractures with a plate. Surgical repair was similar in all patients except that in one group a precontoured locking olecranon plate (LP) was used and in the other group a hook plate (HP) was fashioned by the surgeon using a one-third tubular plate. In both instances the plate was applied to the dorsal surface of the ulna. Measured outcomes include range of elbow motion and complications, including infection, hardware irritation, implant failure, and need for reoperation. Radiographs were reviewed to assess fracture healing. To assess functional outcome, the Mayo Elbow Performance Score (MEPS) was reported for all patients with a minimum of 3 months follow-up. The total cost of each construct as obtained from the manufacturer was calculated.

Results: A total of 32 patients identified over a 5-year period were identified from a trauma database: 16 patients with 16 fractures were treated with an LP and 16 patients with 16 fractures were treated with an HP. The LP group tended to be younger by 11 years ($P = 0.01$). There were no differences in ultimate elbow range of motion, complication rates, and MEPS between groups. There was no difference in rate of complication based on plate type. The average implant cost for the LP was $1174 and the cost of the HP construct was $180.

Conclusion: These data suggest that simple olecranon fractures are well treated with a plate and screw construct. Use of the "no frills" HP alone would have resulted in monetary savings of approximately $1000/case. No clinical advantage was seen with the use of an LP construct in this fracture pattern. Given the increased costs of LPs, these results do not support the use of precontoured locked plates for simple olecranon fractures over a simple hook plate.

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Determination of Clavicle Fracture Displacement Utilizing 3-D Fluoroscopy: A Radiographic Study

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Background/Purpose: A midshaft clavicle fracture is a commonly encountered clinical problem that is often treated successfully with nonoperative means. Recently, clinical studies have found that particular fracture and patient characteristics such as complete fracture fragment displacement with no cortical contact or fractures demonstrating >20 mm of axial shortening benefit from surgical fixation. Accurately determining the extent of displacement and shortening can therefore be important in guiding treatment recommendations. To our knowledge, there have only been two published studies comparing different radiographic views and their accuracy in measuring fracture shortening. However, no study has determined the radiographic view that is best for evaluating fracture displacement. The purpose of this study was to determine the radiographic view that captures the greatest degree of fracture fragment displacement using simulated angled radiographs based on preoperative upright three-dimensional (3-D) fluoroscopy scans in patients with acute midshaft clavicle fractures.

Methods: Ten patients were retrospectively identified from our institution's trauma registry database who had undergone upright preoperative 3-D fluoroscopy imaging for an acute midshaft clavicle fracture. Simulated radiographs ranging from 15° to 50° of angulation in 5° increments were created from the 3-D fluoroscopic scan using the bundled imaging software. The amount of displacement between the fracture fragments for all radiographic images was determined by measuring the distance between the superior cortices at the fracture site of the medial and lateral fragments. Distances were calculated using standard computerized radiographic measurement tools.

Results: Ten patients fulfilled the inclusion and exclusion criteria for this study. The average patient age was 32.9 years of age (range, 18-65) and 7 of 10 patients (70%) were male. Right-sided clavicle fractures occurred in 60% (6) of our patients. 50% of cases (5 of 10) had the greatest measured amount of displacement with a 15° tilted view ($P = 0.004$). The remaining 5 patients demonstrated maximum displacement with differing radiographic angulations. Secondarily, 60% of patients (6) had the least amount of measured displacement with the 50° angulated view ($P < 0.001$).

Conclusion: In conclusion, our retrospective study of patients with an acute midshaft clavicle fracture and preoperative upright 3-D fluoroscopy imaging found that a 15° angulated radiograph demonstrated the greatest degree of fracture fragment displacement. Based on these findings, we recommend obtaining a PA 15° caudal radiograph in the upright position for patients with a midshaft clavicle fracture to best assess the extent of fracture displacement. Accurately identifying the degree of fracture displacement is important as operative management of completely displaced fracture patients has been shown to improve clinical outcomes.

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Outcomes After Plating of Olecranon Fractures: A Multicenter Evaluation

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Background/Purpose: Olecranon fractures are common injuries; however, there are few reports of validated functional outcomes after treatment. Plating has become more popular with the advent of anatomically contoured plates for this region. Some data exist on the success rates, incidence of hardware complications, and outcomes, but they are primarily from small series. The purpose of this study is to report the physical and functional outcomes after open reduction and internal fixation of the olecranon with region-specific plating in a large series with a more robust data set.

Methods: We examined the records of and called patients with displaced olecranon fractures treated operatively with plates at four trauma centers. Patients with associated elbow injuries, such as radial head fracture or dislocation, or other upper extremity injuries were excluded. We documented fracture type, fixation techniques, wound complications, hardware tenderness, plate removal, range of motion, and Disabilities of the Arm, Shoulder and Hand (DASH) scores.

Results: 182 patients (75 women, 107 men) of average age 50 years (range, 16-89) with 163 closed and 19 open displaced olecranon fractures were treated with region-specific plates. Additional small augmentation plates were used in 6.5% of patients and lag screws outside the plate in 26%. Fractures were: transverse (23%), oblique (34%), and comminuted (43%), with 11% having diaphyseal extension. 19 were lost to follow-up leaving 163 for analysis at an average of 38 weeks. All patients united. There was one infection that required irrigation and débridement and the plate was retained. Two patients had partial and one complete wound dehiscence, 2 of which had an irrigation and débridement. The range of motion averaged 11° to 133°, with pronation of 88° ± 7° and supination 87° ± 8°. One patient developed a synostosis and was excluded from this analysis. The most common deficiency was a lack of full extension with 39% lacking at least 10° of extension. Hardware was asymptomatic in 67%, painful upon leaning in 20%, and restricted activities in 11% resulting in a 15% rate of hardware removal. Removal of the plate did not improve range of motion. Hardware complaints were more common if a screw was placed in the corner of the plate ($P = 0.004$). When symptomatic, the area of the plate that was bothersome encompassed the whole plate in 39%, was at the edge of the plate in 33%, and was a screw head in 28%. The incision was asymptomatic in 86%, sensitive in 9%, and bothersome in 5%. The DASH scores for patients in whom it was available was 11.8 ± 16 indicating moderate disability was still present. Patients who lacked 10° of extension had a DASH of 12.3 as compared with 10.5 for those that gained near full extension, but this was not significant ($P = 0.5$).

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Conclusion: Plating of the olecranon leads to predictable union. There were fewer hardware symptoms and lower removal rates than prior reports of tension band wiring, but similar to standard plates and to small series of regional plates, occurring in 15%. The most common complication was lack of full extension with 39% lacking more than 10°, although this did not have any effect on DASH scores. Overall results indicate that disability still exists after 6 months with an average DASH score of 11.8.

See pages 91 - 132 for financial disclosure information.

Factors Affecting Functional Outcome After Scapula Fractures

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Background/Purpose: Despite heightened interest in scapular fracture management among trauma surgeons, injury and patient characteristics that may affect healing and function are poorly defined. Additionally, there is disagreement between the established sets of surgical indications currently proposed. The purpose of this project was to assess parameters that may affect long-term fracture healing and return of shoulder function, including initial fracture classification, treatment (surgical vs nonsurgical), and patient demographics such as smoking and alcohol use. A secondary aim was to propose which patients could benefit from surgical treatment.

Methods: The records of 663 patients with scapular fractures presenting at a Level I trauma center for 14 years were reviewed. 143 women and 420 men with a mean age of 42.8 years were assessed. Data on fracture classification, etiology of injury, comorbidities, alcohol use, and tobacco use were collected. Healing and return to function were assessed through chart review and radiographic review. 139 patients, 123 of whom were treated nonoperatively and 16 treated surgically (open reduction and internal fixation [ORIF]), were also surveyed using the Modified American Shoulder and Elbow Surgeons Score (ASES). Scores were measured out of a possible 100 points, with 0 to 30 representing maximally impaired, 31 to 60 representing moderately impaired, and 61 to 100 representing minimally impaired shoulder function.

Results: With the evidence available there were no patients with clinical or radiographic nonunions. Mean ASES for 139 patients was 80.1 (minimally impaired). Surgically treated patients had a higher mean function score versus nonsurgically treated patients (92.5 vs 79.7; $P = 0.038$). There appeared to be no significant difference in the mean ASES between nonsurgically treated OTA type 09A fractures (no glenoid involvement) and surgically treated 09A fractures (80.0 vs 90.9; $P = 0.15$); further, there appeared to be no significant difference between nonsurgically treated 09B fractures (glenoid involvement) and surgically treated 09B fractures (75.8 vs 96.0; $P = 0.065$). Nonsmokers had a better mean function score than those with a smoking history (83.8 vs 73.3; p = 0.016). Patients with a known history of alcohol abuse had the lowest mean ASES (70.3 vs 83.9, $P = 0.049$).

Conclusion: Patients with scapular fractures are often multiply injured and require a complex set of medical decisions, including the indications for reduction and fixation of the fracture. Retrospective chart and radiographic assessment revealed that surgically and nonsurgically treated scapular fractures, as well as 09A and 09B fractures, had similarly high rates of healing and minimal impairment as measured by mean ASES. While patients managed surgically reported an overall higher function score, there were no significant differences between surgically and nonsurgically treated fractures when sorted by fracture classification. Additionally, patients with current or previous tobacco use or alcohol abuse may experience less return of function, which could suggest chemical, social, or a combination of these factors affecting muscular recovery and/or greater levels of baseline functional impairment.

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Prospective Comparison of Percutaneous Versus Open Technique for the Treatment of Clavicle Fracture Yields Decreased Anterior Chest Wall Numbness

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Purpose: Recent studies demonstrate improved patient outcomes after plating of displaced clavicle fractures; however, many patients complain of anterior chest wall numbness after this procedure. We hypothesize that a patient's measured area of numbness is less after percutaneous fixation than after a traditional open incision, but that this sensory finding would have no effect on shoulder function.

Methods: This is a prospective observational study comparing two cohorts of patients (open vs percutaneous incisions) treated with open reduction and internal fixation (ORIF) of displaced diaphyseal clavicle fractures at a Level I trauma center. Open plating was performed with plate and screws either locking or nonlocking. Percutaneous fixation was performed with two smaller incisions, with a locked plate used to bridge the fracture. The primary outcome was anterior chest wall numbness size (cm^2) as measured with a numbness transparency grid at an initial time point (2 or 6 weeks), 3 months, 6 months, and 1 year after surgery. Secondary outcomes include visual analog scale (VAS) for pain, overall satisfaction, Disabilities of the Arm, Shoulder and Hand (DASH), and Constant scores 1 year postoperatively. Numbness was compared across surgical procedures at the initial and final time points using Wilcoxon rank sum tests. Numbness was also evaluated over time and across surgical procedure using a mixed-effects model. Correlation between secondary outcomes and numbness was evaluated at one-year post-surgery using a Spearman correlation test. All statistical analyses were conducted in R v. 2.15.0 and significance was assessed at a 0.05 level using two-sided tests.

Results: 32 of 35 consecutive patients met inclusion/exclusion criteria, with 100% initial (2- or 6-week) follow-up and 80% for those at least 1 year out from surgery. Initial numbness was common, involving 84% of the open group (average 53 cm^2) versus 62% of the percutaneous group (average 18 cm^2), W = 62.5, $P = 0.019$. Numbness at ` year was also common, involving 56% in the open group (average 19 cm^2) and 33% in the percutaneous group (average 2 cm^2), W = 34, $P = 0.287$. A mixed-effects random intercept model with an auto-regressive correlation structure was used to evaluate numbness over time, revealing that numbness area decreased by about 90% per time point ($t = -3.3$, df = 54, $P = 0.002$) and that area of numbness was on average 2.06 times higher in the open group ($t = 2.2$, df = 30, $P = 0.034$). Numbness at the initial time point predicted a 57% (8/14) and 67% (2/3) chance of continued one-year numbness for open and percutaneous groups, respectively. Constant, DASH, and overall satisfaction remained excellent in all patients at final follow-up, with no significant correlation between numbness and outcome measures ($r = 0.05$ to -0.52, all $P > 0.3$). Final VAS pain scores were also near normal with no demonstrated correlation with surgical technique ($P = 0.39$).

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Conclusion: Anterior chest wall numbness after ORIF of displaced clavicle fractures is very common in the early postoperative period and may remain high 1 year postoperatively. Area of numbness is less at all time points for those treated percutaneously than those treated with a traditional open incision. However, regardless of surgical technique and area of numbness, diminished sensation 1 year after surgery is not associated with poor clinical outcomes.

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Comparison of Outcomes After Triceps Split Versus Sparing Surgery for Extra-Articular Distal Humeral Fractures

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Background/Purpose: Surgical fixation of extra-articular distal humerus fractures (AO/OTA type 13A) has been advocated as it achieves more predictable alignment and potentially quicker return of function. These fractures can be addressed with either a triceps-splitting or triceps-sparing approach. The triceps-splitting approach has the potential to lead to excessive scarring and muscle damage, compromising both elbow motion and strength. The triceps-sparing technique is more technically challenging yet has the potential for improved functional outcomes.

Methods: Skeletally mature patients presenting with AO/OTA 13A fractures between 2009 and 2012 were reviewed and divided into two groups based on surgical approach chosen by the treating surgeon: triceps split (n = 14) or triceps sparing (n = 13). Elbow range of motion and triceps extension strength testing were completed in these patients after clinical and radiographic union. Testing was compared to the unaffected side. All patients were given the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire for functional outcome assessment.

Results: All fractures in both surgical approach cohorts united. The triceps-sparing cohort had better elbow range of motion than the triceps-split cohort, both with improved elbow flexion (143° ± 6° compared to 122° ± 7°, $P = 0.03$) and less extension contracture (8° ± 6° compared to 25° ± 8°, $P = 0.01$). Triceps strength compared to the uninjured arm also favored the triceps-sparing cohort (sparing 87.9% ± 33.3% compared to split 56.6% ± 19.8%, $P = 0.09$). DASH scores, however, were not significantly different between the two cohorts (sparing 15.9 ± 13.2 compared to split 15.0 ± 17.8, $P = 0.83$).

Conclusion: A triceps-sparing approach for surgical treatment of extra-articular distal humerus fractures results in better elbow range of motion and triceps strength than a triceps-splitting approach. However, both approaches result in reliable union and similar functional outcome.

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Quantitative Comparison of Exposure for the Posterior Judet Approach to the Scapula With and Without Deltoid Takedown

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Background/Purpose: Previous studies have described various posterior approaches for scapula fractures; however, no study has formally quantified the access to the bone. These details are important for the preoperative planning of scapula fractures when attempting fracture reduction and fixation. The purpose of this study is to quantify the extent of the scapula exposed and describe the osseous landmarks within the dissection of a posterior Judet approach, with and without detachment of the deltoid muscle.

Methods: Ten posterior Judet approaches utilizing the muscular interval between the teres minor and infraspinatus muscle with and without detachment of the deltoid muscle were performed on 10 fresh-frozen cadaver shoulders. Retractors with 2 lb of force were used at the wound margins for retraction. Upon completion of the exposure, a calibrated digital image was taken from the surgeon's perspective and specific anatomic landmarks were identified. The digital images were then analyzed using a computer software program, Image J, to calculate the area (cm^2) of bone exposed.

Results: The average area of scapula exposed using the traditional Judet approach with takedown of the deltoid muscle was 30.19 ± 4.03 cm^2 (range, 22.74-35.95 cm^2). The average area of scapula exposed using the Judet approach without takedown of the deltoid muscle was 27.33 ± 4.12 cm^2 (range, 19.72-32.96 cm^2). In all 10 cadaver shoulders, the posterior Judet approach without takedown of the deltoid muscle allowed access to the posterior glenoid, lateral scapula border, and spinoglenoid notch.

Conclusion: The posterior Judet approach without takedown of the deltoid muscle allows for safe exposure to 91% of the bony scapula obtained by removing the deltoid muscle. By avoiding detachment of the deltoid muscle, the patient may be spared unnecessary post-operative restrictions and dysfunction, potentially expediting and improving functional outcomes.

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Marginal or Rim Intra-Articular Fractures Involving the Volar Surface of the Distal Radius: A Descriptive Study

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Purpose: This study was undertaken to describe the clinical and radiographic characteristics and the outcomes of shearing intra-articular fractures of the volar rim of the distal radius and compare them to other distal radius fractures (DRFs) that are treated operatively.

Methods: Over a 7-year period a total of 612 consecutive distal radius fractures were treated by members of the trauma and hand divisions at our academic medical center. Shearing articular fractures of the volar rim (VRF) (OTA 23-B3) were identified (n = 29). All patients were treated with open reduction and internal fixation (ORIF) with a volar applied buttress plate and followed up for a mean 11 months. Range of motion measurements and clinical outcome information was collected, as well as Short Form (SF)-36 and Disabilities of the Arm, Shoulder and Hand (DASH) outcome questionnaires. Radiographs were obtained at baseline and at all follow-up intervals. We compared this group to patients from other operatively treated DRFs (n = 267) in order to assess recovery.

Results: There were no differences between groups with regard to patient demographics. Although VRFs were secondary to greater percentage of high-velocity falls (31% vs 22.1%) this difference was not significant ($P = 0.272$). The most common type of volar marginal fracture was simple with a large fragment (OTA 23-B3.2) (44%) followed by multifragmentary (OTA 23-B3.3) (37%). Radiographic measurements were different at injury time but were similarly restored at final follow-up. Improvement of range of wrist and finger motion was evidenced in both groups during follow-up, although specific fracture types in the VRF group had significantly better wrist extension at short-term (OTA 23-B3.1 and B3.2) and finger range of motion at final follow-up (OTA 23-B3.3). SF-36 and DASH questionnaire scores showed no significant differences between both groups ($P = 0.444$ and $P = 0.869$, respectively).

Conclusion: Shearing articular fractures of the volar rim of the distal radius are a rare and unique type of DRF that requires operative intervention. These fractures are well treated with ORIF using a volar buttress plate. Patients can expect a return to function rapidly with minimal risk for complications. VRFs were produced by similar mechanisms as other DRFs and had similar outcomes at long-term follow-up.

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Dorsal Spanning Plate Fixation for Distal Radius Fractures in Polytrauma Patients

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Background/Purpose: The presence of a multifragmentary distal radius fracture in a polytrauma patient with concomitant lower extremity injuries can pose a challenge with respect to early mobilization. We report our experience with the use of a dorsal spanning plate in multiply injured patients with the goal of providing definitive operative fixation for the distal radius fracture as well as for providing a construct to allow weight-bearing through the injured wrist for rehabilitative purposes.

Methods: This was a retrospective review of polytrauma patients with a distal radius fracture treated with a dorsal spanning plate by the senior author over a 6-year period from 2006 to 2012. Only those patients who had returned for removal of the implant were included. Medical records were reviewed to evaluate functional and radiographic outcomes as well as complications associated with the procedure.

Results: A total of 33 patients were identified, 20 male and 13 female. The mean age of the patients was 52 years (range, 23-79 years). The mechanism of injury was a motor vehicle accident in 9 patients, a mechanical fall in 6 patients, and a fall from height in 18 patients. There were 5 patients who had sustained bilateral distal radius fractures. The median time from injury to operative fixation was 3 days. Patients returned to the operating room for removal of the plate at a median interval of 4.3 months (range, 2.5-15.9 months). Only 5 of the patients retained the implant for more than 7 months. There were no cases of tendon rupture or infection. Implant failure was noted in 3 patients; however, these patients had retained their plate for a mean interval of 13.4 months. Average functional outcomes at a mean of 5.8 months following removal of the plate were 48° of flexion, 47° of extension, 78° of pronation, 72° of supination, 14° of radial deviation, and 20° of ulnar deviation. Mean radiographic outcomes were radial inclination of 19.2°, radial length of 10.2 mm, ulnar variance of –0.16 mm, and a palmar tilt of 5.8°.

Conclusion: A preliminary analysis of our experience with the procedure is encouraging. Functional and radiographic outcomes are comparable to values reported in the literature for patients with similar high-energy injuries who were treated with spanning external fixation or volar plating.

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Preexisting Osteoarthritis Does Not Affect Outcome in Distal Radius Fractures

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Background/Purpose: Distal radius fractures are very common in osteoporotic patients. Functional outcomes of these patients vary widely regardless of treatment method. Multiple predictive factors such as age, residual deformity, and distal radioulnar joint congruence have been identified. The hypothesis of this study is that preexisting carpal osteoarthrosis will negatively impact functional outcome in patients with distal radius fractures.

Methods: A case control study was done using a prospective trauma database. Patients were matched 1:1 with or without wrist osteoarthritis (OA) in two groups based on surgical or nonsurgical treatment. Patients with residual significant displacement, open fracture, nerve injury, postoperative infection, and additional ipsilateral injuries were excluded. OA was classified using the Kellgren-Lawrence system. Patients' functional outcomes were assessed at minimum 1 year postfracture using validated scores. Sample size (52) was calculated using a power of 0.8 and alpha of 0.05. The Patient-Rated Wrist Evaluation (PRWE) was the primary outcome and mean standard deviation is 20 according to literature. We look for a significant difference of 15 points on 100 for PRWE.

Results: A total of 54 patients with 40 women were included. Mean age was 63 (range, 20-80) and average follow-up was 2.5 years (range, 1-5.). There were 35 patients treated surgically and 19 nonoperatively. A total of 26 patients had OA (OA+) and 28 patients presented with no OA (OA–). No patients without initial OA went on to develop OA during follow-up. Both groups (OA+ and OA–) were comparable for sex, residual deformity, treatment type, and follow-up. Despite recruitment efforts, there was significant difference in age. Overall, no significant differences in outcomes were found between OA+ and OA–. QuickDASH (an abbreviated version of the Disability of the Arm, Shoulder and Hand [DASH] score and PRWE correlated highly together (*P* <0.001). A post hoc power analysis revealed power of 0.99 and a beta of 0.01.

Criteria*	OA+ (SD)*	OA- (SD)	*P*
Age	67 (8)	58 (11)	0.001
Sex	77%	71%	0.7
Follow-up	2.3 y (0.8)	2.6 (0.8)	0.2
PRWE	16 (25)	20 (23)	0.5
QuickDASH	15 (23)	19 (23)	0.6
SF12P	46 (12)	47 (11)	0.8
SF12M	48 (9)	46 (11)	0.6
VAS	1.4 (2.4)	2.0 (2.6)	0.4

*SF12P = Short Form-12 physical; SF12M = Short Form-12 mental;
VAS = visual analog scale; SD = standard deviation.

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Conclusion: While many factors can influence outcomes in distal radius fractures, preexisting OA seems to have no impact on outcomes regardless of treatment, age, or sex. We believe that this should not dictate treatment decision. While this is a negative study, the result remains important to find potential causes of negative outcomes. This study is very well powered with the chance of a bigger study showing any difference at less than 1%.

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An Evaluation of Possible Prophylactic Therapies for the Prevention of Posttraumatic Joint Stiffness

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Purpose: This study was undertaken to compare the efficacy of possible prophylactic therapies for prevention of the formation of posttraumatic joint contractures and/or adhesions.

Methods: In 60 rats the soft tissue on the medial and lateral condyles and the cartilage of the trochlea was incised and scraped with a scalpel blade, and the knee was immobilized in flexion for 2 weeks. Treatments of corticosteroid or hyaluronic acid by intra-articular injection (postoperative days 1, 3, and 7), whole body vibration (5 days a week), or oral montelukast (every day) were administered. After sacrifice the legs were disarticulated at the hip and immobilization angles were measured by x-ray with the immobilizing suture intact. All other measurements were made with a 0.015-Nm extension moment applied to the knee. Pictures were taken and angles were measured digitally, comparing the operated leg to the contralateral limb to standardize each result.

Results: We found a prophylactic effect in three of our four treatment groups. Although the steroid-injected group of rats lost weight and had a high mortality, quantitative analysis showed a much smaller difference between the operated and nonoperated legs in both the "suture cut" and "posterior capsule cut" measurements when compared to control. Treatment with hyaluronic acid or vibration therapy resulted in smaller but still significant differences in the posterior capsule cut measurements. No significant differences in any of the measurements were detected in the montelukast group.

POSTER ABSTRACTS

Table 1: Degrees difference between right and left knees[a]

	Suture Cut	Posterior Capsule Cut
STER	5 ± 5[b]	5 ± 6[b]
HA	37 ± 12	23 ± 11[b]
VIB	36 ± 15	24 ± 15[b]
MLK	40 ± 10	27 ± 9
CTRL	39 ± 8	33 ± 14

[a]The "suture cut" measurement was taken after removing the suture, fibula, and posterior musculature around both knees. The "posterior capsule cut" measurement was taken after transecting the posterior capsule when the cruciate and collateral ligaments and any intra-articular adhesions were the only structures still limiting extension. STER = triamcinolone acetonide, HA = hyaluronic acid, VIB = vibration, MLK = montelukast, CTRL = saline.

[b]Significant difference relative to the control group ($P<0.05$)

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Conclusion: Steroid injection markedly inhibited arthrofibrosis while hyaluronic acid injection and vibration therapy also inhibited stiffness, but to a lesser degree. Further research should be undertaken before these techniques are considered in human subjects.

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•Sustained Intra-Articular Delivery of IL-1Ra From a Thermally Responsive Polypeptide Depot Prevents Posttraumatic Arthritis in Mice

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Background/Purpose: Proinflammatory cytokines such as interleukin-1 (IL-1) and tumor necrosis factor alpha (TNF-α) are upregulated following joint trauma and have been implicated in the pathogenesis of posttraumatic arthritis (PTA). Presently, surgical restoration is the only treatment for articular fractures. We hypothesize that anticytokine therapy using local sustained inhibition of IL-1, TNF-α, or both IL-1 and TNF-α can prevent the development of PTA following articular fracture.

Methods: Using an Institutional Animal Care and Use Committee–approved protocol, male C57BL/6 mice (n = 77) were subjected to an articular fracture at 16 weeks of age using an established model and separated into 5 groups (n = 12-16/group). One group received no treatment after fracture (Fx). The other four groups received intra-articular (IA) injections of phosphate-buffered saline (PBS), IL-1 receptor antagonist (IL-1Ra; anakinra), soluble TNF receptor II (sTNFRII; etanercept) or both IL-1Ra + sTNFRII immediately following Fx. The drugs were encapsulated in elastin-like polypeptide (ELP) drug depots that slowly disaggregate for prolonged IA delivery. Mice (n = 6-8/group) were sacrificed at 4 and 8 weeks. Micro-CT of both limbs was performed to assess bone morphology. Histological sections of joint tissue were then evaluated for cartilage degeneration using a modified Mankin score and synovial inflammation using a modified synovitis score. Nonparametric statistical analyses were performed for histologic measures, and parametric analyses were performed for bone morphological measures.

Results: IA delivery of IL-1Ra reduced cartilage degeneration (Figure 1). However, both groups that received sTNFRII showed a detrimental effect in cartilage degeneration, synovial inflammation, and bone morphology. Additionally, IA delivery of IL-1Ra reduced synovial inflammation at 8 weeks and had no detrimental effects on bone healing.

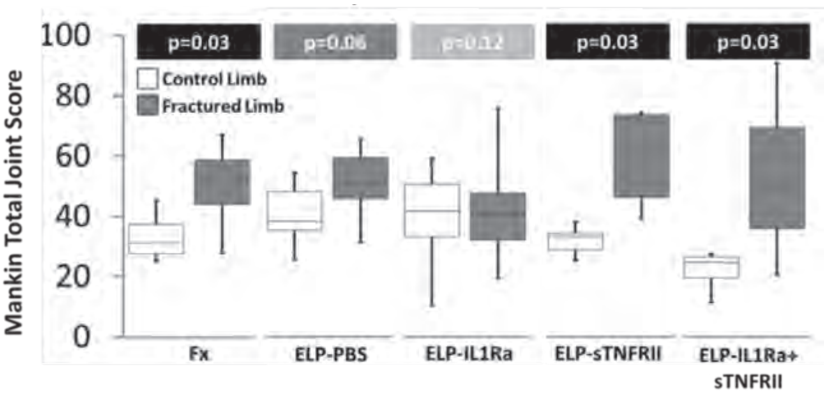

Figure 1. Mankin score of histologic degenerative joint changes at 8 weeks post-fracture.

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Conclusion: Sustained IA inhibition of IL-1 reduced the severity of arthritic changes in both cartilage and joint tissue. However, the inhibition of TNF-α resulted in detrimental bone morphological changes, loss of cartilage, and inflammation of joint tissue. This study shows that the inhibition of proinflammatory cytokines after trauma using IA delivery of a thermoresponsive hydrogel has the potential as a therapy for PTA.

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Clinical Validation of an In Vivo Rat Model for the Study of Blast-Induced Heterotopic Ossification

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Background/Purpose: Heterotopic ossification (HO) is a devastating complication that frequently accompanies orthopaedic trauma. Once HO is identified, the only definitive treatment for symptomatic patients is excision of the offending ectopic bone. Although existing methods for preventing HO are highly effective, they are incompatible with the nonacute trauma setting. An early warning system for HO would enable targeted prophylaxis for the most at-risk patients. Previous models of HO are not specifically relevant to the mechanisms of wartime extremity injury. However, a recent study showed Sprague-Dawley rats exposed to a prescribed-intensity blast reliably produce HO in the amputated limb. Our hypothesis is that the processes of HO seen in both civilian practice and war trauma share a similar biology, and the biologic events that characterize HO in a blast amputation model using Sprague-Dawley rats will closely resemble those observed in battle-injured soldiers who develop HO. Correlation of animal and human HO findings will provide a tool for identifying common early-presenting biomarkers indicative of HO formation in wounded soldiers at greatest risk.

Methods: *Human tissue:* Surgical waste tissue was obtained from consented patients injured during the current war on terror following a protocol approved by the WRNMMC IRB. *Rat tissue:* Sprague-Dawley rats were exposed to blast using a previously described protocol. These rats were sacrificed at 7 and 14 days following blast treatment and tissue from the zone of injury was then analyzed in an identical manner as previously described for human tissue samples.

Results: Histological and gene expression analysis revealed that human and rat tissue exhibit similar intramuscular fibrotic tissue development following blast injury. Picrosirius red staining of blast-injured muscle tissue with polarized (left) and bright-field (right) microscopy (Figure 1) revealed the formation of fibrotic tissue within 14 days of injury. Within 2 to 3 weeks following blast trauma, the differential gene expression pattern in the regenerating muscle tissue is similar for rats and humans (Figure 2). This includes key genes associated with ectopic bone formation: activin A (ACTA), bone morphogenetic proteins (BMPs), and tumor necrosis factor (TNF).

Conclusion: We believe our previous work has defined key events in the etiology of trauma-induced HO, and our recent data suggests that the biomolecular mechanisms contributing

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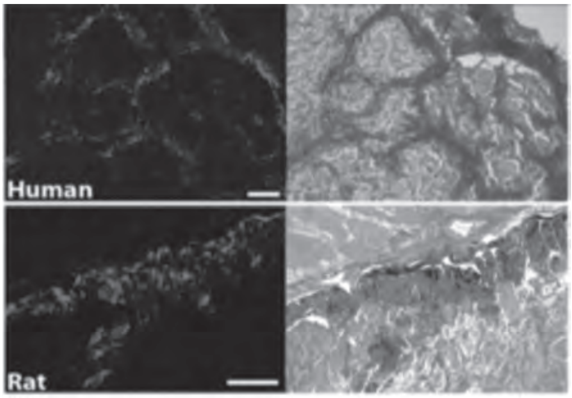
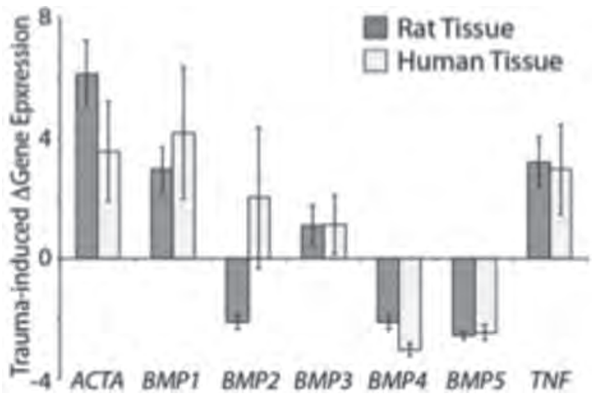
to HO in the rat model may be well aligned with those in the human clinical condition. These results validate this in vivo rat model; will aid in the development of novel, targeted therapeutics; and can eventually help identify individuals at high risk of developing HO in both the military and civilian setting.





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Assessment of Osseous Incorporation of Endosteal Fibular Allograft Used to Augment a Fixation Construct for Femoral Neck Fractures: An In Vivo Magnetic Resonance Imaging Study

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Background/Purpose: Endosteal fibular strut allografts provide supplemental structural support and stability in the treatment of periarticular fractures. Specifically, we sought to assess osseous incorporation of an endosteal fibular allograft used as part of a fixation construct for femoral neck fractures (FNFs). Host responses to the allograft and its biological viability have not been determined. Using a special sequence of contrast-enhanced MRI, we aimed to evaluate osseous incorporation and biologic changes that occur (1) at the interface of the fibular allograft and host bone and (2) within the fibular allograft itself.

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Methods: 19 patients (13 females, 6 males) with displaced FNFs treated with open reduction and a length-stable construct using an endosteal fibular allograft serving as a "biologic screw" were prospectively enrolled. Mean patient age was 60 years (range, 29-78). Postoperative MRI, using the multi-acquisition variable-resonance image combination (MAVRIC) sequence, was obtained at two time points (3 months and 12 months after surgery). This sequence minimizes metal artifact, facilitating qualitative and semiquantitative assessment of fibular allograft osseous incorporation and relative perfusion, respectively. Osseous incorporation was qualitatively assessed by an experienced musculoskeletal MRI radiologist in 3 grades (none, partial and very good / complete) for each time point (Figure 1). In addition quantitative assessment of the fibular allograft was performed using pre- and post–contrast-enhanced T1-weighted MAVRIC images. Signal intensity (SI) enhancement (semiquantitative perfusion) was measured in the medullar segment of the fibular allograft (Figure 2), and controls at the ilium and femoral diaphysis at both time points. All measurements were corrected for cortical bone; a percentage of SI uptakes was calculated and then compared between the regions of interest and over time using a paired, two-tailed Student *t* test.

Figure 1: Example of each of the three categories of osseous incorporation categories: (i) none (left); (ii) partially (middle); (iii) very good / complete (right).

Results: One patient suffered catastrophic failure and was converted to a total hip arthroplasty. The remainder of patients maintained near anatomic reduction and achieved osseous union (95%). We obtained MRI at both time points (3 and 12 months) in 12 patients, 3-months MRI in 17

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patients, and 12-month MRI in 16 patients. Either partial (44%; 7 of 16) or complete (38%; 6 of 16) osseous incorporation was noted in 81% (13 of 16) of the patients at 12 months. No incorporation was noted in 47% (8 of 17) and 19% (3 of 16) of patients at 3 and 12 months, respectively. At 3 months, there was no statistically significant difference in %SI uptake in the bone graft when compared to the ilium and the femoral diaphysis. However, at 12 months, a significantly increase in %SI uptake was noted in the bone allograft. There was a significant increase in %SI uptake within the fibular allograft at the 12-month interval after surgery compared to 3 months (Figure 3). No MRI signs of adverse reaction of the host (synovitis, periallograft edema, or osteolysis) to the allograft were observed.

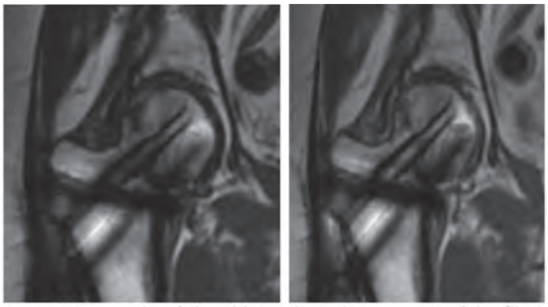

Figure 2. Example of signal intensity enhancement of the fibula allograft. MAVRIC contrast enhanced MRI at 12-months. Pre- Contrast (Left); Post-Contrast (Right)

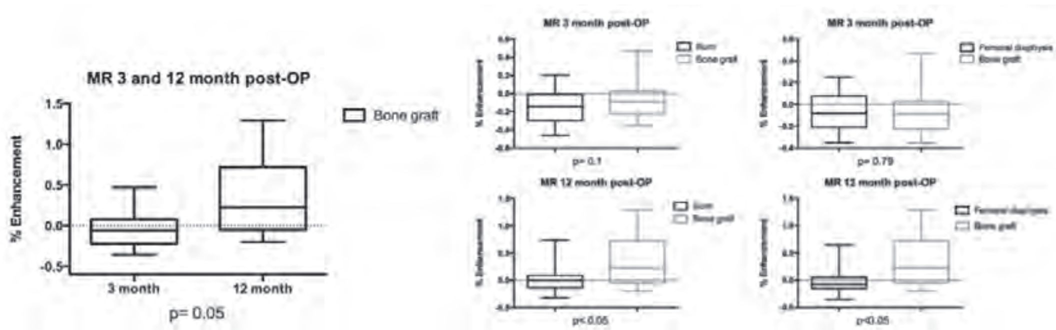

Figure 3. Percentage enhancement, corrected for cortical bone, of the fibular allograft over time (left) and versus ilium and femoral diaphysis (Right) at 3- and 12- months post-operatively.

Conclusion: Based on these preliminary qualitative and semiquantitative findings, our study demonstrates a fibular allograft used in a length-stable construct to treat FNFs seems to undergo biologic changes indicative of osseous incorporation and revascularization over time. These changes may translate into a construct that increases in strength/stability at the host-allograft interface over time. In contrast, a screw-bone interface weakens over time, decreasing in strength and stability of the construct. This type of biologic implant may improve the surgical treatment of periarticular fractures, particularly FNFs. Additional studies are needed to further validate our findings and assess effect on functional and radiographic outcomes.

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Determination of Relative Radiation Exposure From C-arm Fluoroscopy Views Taken During Orthopaedic Trauma Operations: A Pilot Study

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Purpose: In orthopaedic surgery, fluoroscopy is used extensively for indirect visualization. Despite its increasingly common use, data are limited regarding radiation exposure from different fluoroscopy views used during orthopaedic trauma procedures. This study measured relative radiation exposures between different fluoroscopy views commonly taken during orthopaedic trauma surgery.

Methods: One full-body cadaver specimen was used for this study. 42 fluoroscopy views commonly shot during orthopaedic trauma cases were taken. Radiation scatter was measured using 6 real-time dosimetry badges. The badges were positioned on two poles, one representing the surgeon (S1) and one representing the assistant surgeon (S2). Three badges were placed on each pole: table height, 1 ft above table height, and 1 ft below table height. One minute of continuous fluoroscopy was taken for each view in order to gain sufficient radiation exposure.

Results: The results were compiled as the average radiation exposure of the three badges for S1, the three badges for S2, and as the average of all 6 badges. The results were expressed as relative values compared to the exposure from the distal radius AP view. S2 received less radiation exposure than S1 in 33 of the 42 views. Using the average of all 6 badges, 7 views had over 50 times the radiation exposure of the distal radius exposure and 10 additional views had over 10 times the radiation exposure as a distal radius AP. The highest radiation exposure was from thoracic spine lateral followed by lumbar spine lateral. Of the non-spine views, the pelvic outlet view and the pelvic iliac oblique view resulted in the highest radiation exposure.

Conclusion: In this pilot study, there was a wide range of radiation exposure depending on the fluoroscopy view as well as the position of the dosimeters. Lateral spinal views as well as pelvic views led to the greatest radiation exposure. S1 received more radiation exposure than S2 on most exposures. Additional specimens will allow added precision of relative radiation exposure from different views and help account for anatomic variability. These data should help orthopaedic surgeons to minimize their radiation exposure in routine trauma procedures.

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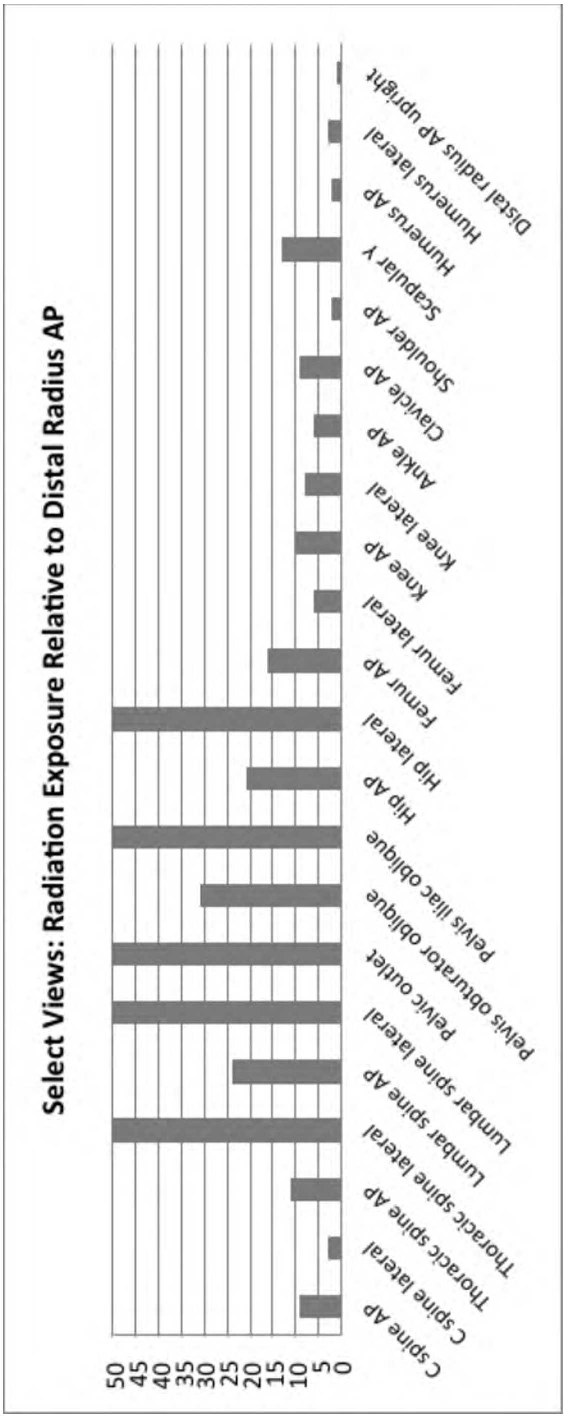

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Biomechanical Comparison of Locked Plating and Spiral Blade Retrograde Nailing in Osteoporotic Supracondylar Femur Fractures

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Background/Purpose: Comminuted supracondylar femur fractures in the elderly are often treated with either retrograde femoral nailing or locked plating methods. Whereas early weight bearing is nearly always allowed after fixation of proximal femur fractures, it typically restricted after fixing supracondylar fractures, impairing the patient's mobilization. Surgeons are more comfortable allowing early weight bearing after nailing rather than plating, but early studies of retrograde femoral nails using standard distal locking showed poor fixation compared with locked plating. Newer generation distal locking techniques, such as the distal spiral blade, may demonstrate improved fixation, potentially allowing early weight bearing. The purpose of this study is to biomechanically compare locked plating (LCP) with spiral blade retrograde nailing (RFN) of osteoporotic supracondylar femur fractures with simulation of a postoperative course of full weight-bearing.

Methods: 10 pairs of cadaveric femurs were used: 5 pairs with a normal bone mineral density (BMD) (average 0.92 g/cm^2, standard deviation [SD] 0.05) and 5 pairs with osteopenia or osteoporosis (average 0.5 g/cm^2, SD 0.2). Right-sided specimens were fixed with the RFN with spiral blade and screw distal locking and left-sided specimens were fixed with the LCP according to the surgical protocol (with all screws locked). A 3-cm metaphyseal gap osteotomy was performed afterwards to simulate a highly comminuted type A supracondylar femur fracture. Testing was performed in order to best simulate physiologic loading in a 70-kg individual. Each specimen was subjected to cyclic axial compression (200,000 cycles) to simulate 6 weeks of postoperative recovery and the permanent deformation and axial stiffness of the constructs were measured.

Results: Among subjects with low BMD, the RFN specimens had an average permanent "toggle" of 4.68 mm, 1.6 mm more than the LCP implant ($P = 0.04$), whereas among subjects with normal BMD, the nail implants deformed an average of 1 mm, 0.1 mm more than the LCP implant ($P = 0.03$). Axial stiffness was significantly higher for specimens fixed with the LCP compared to the RFN, a 127-kg force (kgf)/mm difference for normal BMD specimens ($P = 0.005$) and a 48-kgf/mm difference for low BMD specimens ($P = 0.008$).

Conclusion: The RFN with spiral blade locking had significant loss of fixation compared with the LCP in an osteoporotic supracondylar fracture model when subjected to postoperative gait–simulated testing. Furthermore, a substantial improvement in axial stiffness was seen with the LCP, particularly in osteoporotic bone. Whereas the differences are less in normal bone, these data suggests that even with enhanced distal fixation, RFN involves increased loss of fixation in osteoporotic bone compared with locked plates. It is not clear whether or not these differences are clinically significant. Although physiologic gait simulation was attempted, clinical correlative studies would be needed before suggesting the safety of immediate full weight bearing of supracondylar femur fractures in osteoporotic bone with either device.

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An Innovative Culture System for the Study of Heterotopic Ossification

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Background/Purpose: Following orthopaedic trauma, injured muscle tissue becomes populated with mesenchymal progenitor cells (MPCs) hypothesized to play a key role in wound healing pathologies such as heterotopic ossification (HO). During recent military operations, there has been a significant increase in the prevalence of heterotopic ossification in the combat-wounded patient population with rates as high 64%. We hypothesize the physical microstructure (fibrosis) within a wound dysregulates muscle regeneration, working synergistically with inflammatory factors to confuse local MPC populations and generate an early osteoinductive region. In this study, we examine the structure of decellularized early-stage traumatized muscle tissue taken from patients who develop HO and identify noncellular structural components that may be instrumental in pathological wound development and create a biomimetic in vitro culture platform replicating the wound microarchitecture to create an in vitro model system for studying the development of HO.

Methods: *Tissue decellularization:* Surgical waste muscle tissue was obtained from consented patients injured during Operation Enduring Freedom; these patients were radiographically observed as developing HO in subsequent months. Tissue was sectioned into 5-mm^3 segments and incubated overnight in 0.1% sodium dodecyl sulfate (SDS) surfactant solution to remove all cellular and lipid components characterized using scanning electron microscopy (SEM) and replicated the microstructure by electrospinning collagen. *Cell isolation and culture:* MPCs were harvested from traumatized muscle by plastic-adherence methodology and expanded on collagen-coated and fiber matrix dishes for 3 weeks, before ensuing culture in osteogenic media (Invitrogen) for 2 weeks. Calcium deposition was measured with alizarin red, and osteoblast activity was assayed with alkaline phosphatase. Protein lysates were also collected for Western blotting analysis.

Results: We have evaluated the physical microenvironment of traumatized muscle tissue in patients radiographically confirmed to form HO by lysing all cellular components from the tissue, leaving a preponderance of nanofiber matrix. This nanofiber component was identically replicated with electrospun collagen scaffolds. MPCs cultured on this fiber surface have a significantly increased osteogenic potential, with greatly increased calcium deposition (as measured by alizarin red) and alkaline phosphatase expression compared to cells cultured on 2-dimensional collagen. Western blotting analysis revealed increased vimentin expression for MPCs cultured on fiber substrates prior to osteogenesis, as well as a decrease in alpha smooth muscle actin (αSMA), a prominent fibroblast marker. Vimentin has been shown to be essential for cartilage formation, which is hypothesized to precede endochondral ossification of HO. It has also been shown that decreases in vimentin cor-

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relate with osteoblast differentiation and bone formation, perhaps acting as a trigger for osteocalcin signaling.

Conclusion: Our experimental results show a robust increase in calcium secretion from MPCs cultured on a biomimetic nanofiber matrix. The increase in vimentin expression before osteogenic induction correlates well with literature, with a corresponding decrease in fibrotic markers (αSMA) indicating a shift into preosteogenic state. The sensitivity of osteogenic phenotype to the nanofiber matrix suggests that it is likely a key component for properly elucidating HO development using in vitro cellular models.

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A Safe Technique for Dynamizing the Taylor Spatial Frame

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[2]University of Miami, Coral Gables, Florida, USA;
[3]Max Biedermann Institute for Biomechanics, Miami Beach, Florida, USA

Background/Purpose: Dynamization of external fixation can be achieved by allowing axial micromotion to occur with loading of the frame. The Taylor Spatial Frame (TSF) uses six obliquely oriented struts to connect the rings. These struts allow correction of deformity to occur in all planes of motion. However, attempting to dynamize the TSF by loosening the struts may not be appropriate for fracture or osteotomy healing. Our hypothesis is that dynamization of the TSF by loosening struts will create excessive shear loading on the fracture gap, but modified shoulder bolts will provide controlled axial micromotion.

Methods: Five TSF constructs were mounted on Sawbones tibiae with a proximal ostectomy. An axial load aligned to the mechanical axis of the tibia was cycled from 20 to 200 N at 0.25 Hz. 6 degrees of freedom of motion of the proximal and distal segments were tracked (Figure 1) for 8 different constructs: (1) all struts of the TSF intact; (2) strut 1 loose; (3) struts 1 and 3 loose; (4) struts 1, 3, and 5 loose; (5) all struts loose; (6) all struts intact with dynamization bolts on the proximal side; (7) all struts intact with dynamization bolts on alternating sides; and (8) threaded Ilizarov rods locked between the rings.

Results: There was no statistically significant difference in vertical displacement between the Ilizarov rods and all struts locked. There was a statistically significant difference between the modified shoulder bolts and the Ilizarov rods (P <0.01) and all struts locked (P <0.05). There was no statistically significant difference in shear values between all struts locked and the modified shoulder bolt struts. There was a statistically significant difference in shear values between one strut unlocked and all struts locked / dynamized (P <0.05) (Figure 2).

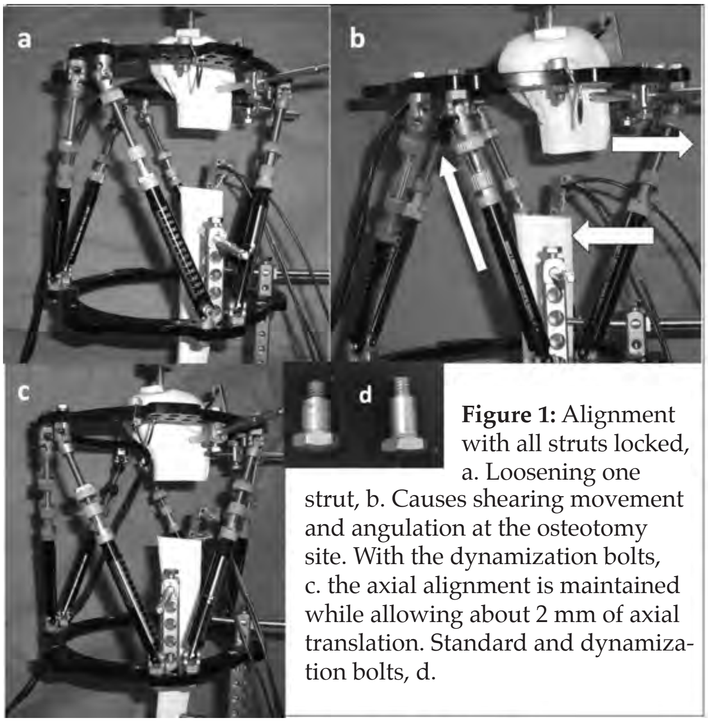

Figure 1: Alignment with all struts locked, a. Loosening one strut, b. Causes shearing movement and angulation at the osteotomy site. With the dynamization bolts, c. the axial alignment is maintained while allowing about 2 mm of axial translation. Standard and dynamization bolts, d.

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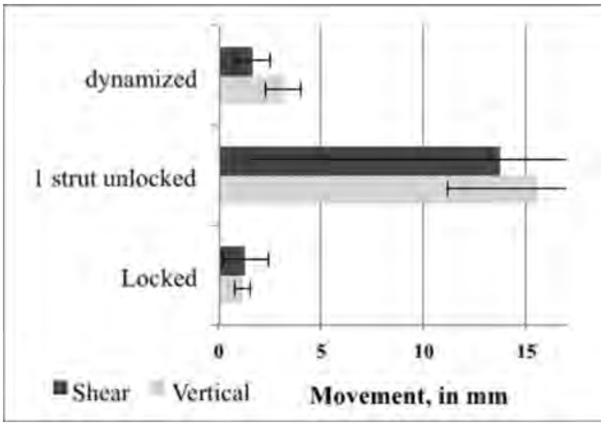

Figure 2: Measurable movements with the frame locked were about 1 mm. With dynamization bolts, the vertical movement increased by about 2 mm. Unlocking one strut caused gross motion.

Conclusion: The modified shoulder bolts may be a safe (and easy) way to dynamize the TSF. They allow appropriate axial motion without a significant increase in shear. It is not recommended to unlock a single or multiple struts as a method of dynamizing the Taylor Spatial Frame.

•Relationship of Intramuscular Tissue Oxygenation and Muscle Viability in a Compartment Syndrome Model

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Background/Purpose: The diagnosis of acute compartment syndrome (CS) remains problematic and often missed due to lack of objective criteria to measure the viability of muscular tissue. Continuous measurement of intramuscular tissue oxygenation (PmO_2) of the leg has been shown to be feasible in humans and highly responsive to induced CS and fasciotomy in a dog model. Using the same model, we investigated the relationship between PmO_2 after fasciotomy and biochemical measurements of tissue viability.

Methods: Under general anesthesia, CS was induced in the anterolateral compartment of one leg in 4 animals via Hespan infusion with a goal pressure 30 mm Hg above diastolic blood pressure. Polarographic oxygen probes were placed percutaneously into the anterolateral compartment. PmO_2 was recorded every 30 seconds. After approximately 7 hours of CS, fasciotomy was performed. Animals were euthanized 2 weeks postoperatively at which point muscle biopsies were performed. Tissue viability was assessed by histologic analysis (hematoxylin and eosin, Masson's trichrome, cytochrome c oxidase stains) and MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) assay, which is a validated technique in which viability is expressed as a percentage of control.

Results: Mean duration of compartment syndrome was 6.9 hours. The average mean PmO_2 was 35.63 mm Hg (range, 15.22-53.65) and decreased to 2.54 mm Hg (range, 0.19-4.92) during induced CS ($P = 0.06$). Following fasciotomy, 2 animals showed recovery exceeding a threshold PmO_2 of 10 mm Hg and 2 animals did not. The animals with persistent low PmO_2 had substantially more fibrosis on histologic analysis (collagen fiber:muscle tissue ratio 45.58% vs 21.98%, $P = 0.01$) and lower viability index (9.23% vs 44.41%, $P = 0.1$) at 2 weeks.

Conclusion: The PmO_2 values following fasciotomy appear to reflect underlying muscle viability as confirmed by histologic methods with use of a previously suggested threshold PmO_2. This is an important finding if PmO_2 is to be used to guide the treatment of CS. Measurement of intramuscular tissue oxygenation detects pressure-induced ischemia and may also predict irreversible necrosis in an animal model with high translational potential. It may represent a minimally invasive, physiologic, and continuous method for diagnosing compartment syndrome.

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Are Hook Plates Advantageous to Antiglide Plates for Vertical Shear Malleolar Fractures?

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Purpose: The purpose of this project is to evaluate the biomechanical properties of the hook plate versus the antiglide plate in the treatment of the supination-adduction (SAD) ankle fracture.

Methods: Fourth generation polyurethane models of the left tibia were obtained and subjected to pretesting stiffness. Identical vertical fractures of the medial malleolus were created. The fractures were stabilized with one of the following constructs: a one-third tubular plate in an antiglide fashion with two screws proximal to the fracture (TwS), the one-third tubular plate with two screws proximal to the fracture and with an additional screw perpendicular through the vertical shear fragment (ThS), or a hook plate (HP). Ten models were randomly assigned to each of the three groups. The constructs were tested in offset axial loading to simulate loading in supination. The constructs were evaluated for construct stiffness and load to failure.

Results: The ThS construct yielded higher stiffness versus the TwS (P <0.05) and the HP (P <0.05). The plate stiffness of the HP construct compared to the TwS was not significant (P = 0.350). When analyzing absolute load to failure, the difference between ThS and TwS was 638 N and between ThS and HP was 530 N (P <0.05). The HP had a load to failure that was on average 108 N more than the TwS, but this was not significant (P = 0.063).

Conclusion: This study examined the biomechanical properties of a traditional fixation (TwS group), a commonly used fixation (ThS group), and a newer construct (HP group). The HP group is unique to this study and to our knowledge there is no literature on this type of fixation for this fracture. Antiglide plating technique with an additional screw placement (ThS) is biomechanically superior to the other two constructs investigated in terms of stiffness and absolute load to failure for fixation of vertical shear medial malleolus fractures. This construct represents strong, stable support for this fracture.

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Delivery of Jagged1 Immobilized to a Scaffold Stimulates MSC Osteoblast Differentiation

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University of Pennsylvania, Philadelphia, Pennsylvania, USA

Background/Purpose: Up to an estimated 10% to 13% of fractures result in nonunion. Common therapeutics including autologous bone grafts and bone morphogenetic proteins among others all have limitations. Therefore, a need persists for the development of new therapies to enhance bone regeneration. The Notch signaling pathway regulates bone repair and we have previously demonstrated that the Notch ligand Jagged1 is the most highly expressed Notch ligand during repair. Therefore, the objective of this study was to investigate Jagged1 as a translatable therapeutic by evaluating its ability to induce osteoblast differentiation in a clinically relevant tissue culture model.

Methods: Jagged1 was diluted in phosphate buffered saline (PBS) at 0, 2.5, and 10 μg/mL and immobilized to a poly(β-amino ester) polymer (A6) via adsorption (Jagged1/A6: 0/A6, 2.5/A6, 10/A6). Primary human bone marrow-derived mesenchymal stem cells (hMSCs) were cultured in (1) standard growth media (SGM: αMEM [minimum essential medium alpha], 20% FBS [fetal bovine serum], l-glutamine, pen/strep) to determine the ability of Jagged1 to activate the Notch signaling pathway and promote osteogenic gene expression and enzymatic activity; or (2) in osteogenic media (OGM: αMEM, 10% FBS, l-glutamine, pen/strep, 200 μM ascorbic acid 2-phosphate, 100 mM β-glycerophosphate, 100 nM dexamethasone) to determine the ability of Jagged1 to induce calcified mineral deposition, which is indicative of terminal osteoblast differentiation.

Results: hMSCs were viable on Jagged1/A6 constructs and continued to grow over time (Figure 1, A). Jagged1 increased expression of Notch target gene Hey1 in a dose-dependent response (Figure 1, B). Jagged1 similarly increased bone sialoprotein (BSP) gene expression and alkaline phosphatase (Alk Phos) enzymatic activity (Figure 1, C). Interestingly, there was a positive and significant linear correlation between Hey1 and BSP gene expression, suggesting that Jagged1-induced Notch activation promotes osteogenic activity. Most importantly, Jagged1 increased calcified mineral deposition by hMSCs, indicating that Jagged1 induced terminal osteoblast differentiation (Figure 1, D).

Conclusion: The Notch ligand Jagged1 is an osteoinductive protein, with potential as a therapeutic bone regenerate. Future studies will evaluate the ability of Jagged1 immobilized to a clinically utilized osteoconductive scaffold to induce bone formation and regeneration in vivo.

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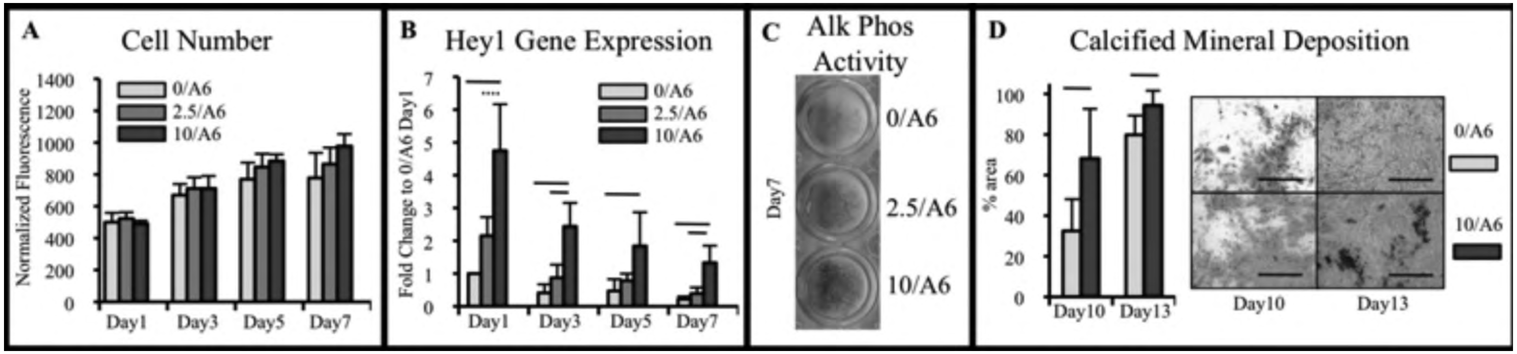

Figure 1: Cell number (A), Hey1 gene expression (B), Alk Phos activity (C), and calcified mineral deposition (D) of hMSCs cultured on Jagged1/A6 biomaterial constructs at 0, 2.5, and 10 μg/mL.

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Early Risk Stratification for Wound Specific Heterotopic Ossification Formation in Combat Casualties

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Introduction: Heterotopic Ossification (HO) is the formation of mature lamellar bone in non-osseous tissue. We reported previously that 64% of combat casualties developed clinically significant heterotopic ossification, which is far greater than that reported in the civilian literature. In other analyses, HO emerged as the single most important barrier to meaningful functional mobility, independence, and return to military service. Symptomatic HO can be treated conservatively in the majority of cases, however, a large number require surgical excision, a procedure that is potentially debilitating and fraught with complications. Means of primary prophylaxis (Non Steroidal Anti Inflammatory Drugs and Radiotherapy) exist, but are associated with undesirable side effects in our combat wounded patient population. Furthermore, there are no reliable means by which risk stratify patients and predict which wounds are likely to form HO. The purpose of this study was to develop a robust, clinically useful prognostic model to estimate the likelihood of wound-specific HO formation in combat casualties early in the wound reparative process.

Methods: We examined 88 wounds in 72 combat wounded patients over a 6 year period. Muscle biopsies were obtained during the initial debridement procedure within the continental United States. From these, we assessed the gene transcript expression of 190 wound healing, osteogenic, and vascular genes using a custom design. Each was quantified by normalizing to the 18s expression. Using these data, we developed two models, a logistic regression (LR) and an artificial neural network (ANN), to estimate the likelihood of wound-specific HO formation. For the LR model, only potentially significant variables identified on univariate analysis were entered into the multivariate model. We developed the artificial neural network (ANN) model using the Oncogenomics Online Artificial Neural Network Analysis system, which uses feed-forward resilient back-propagation multilayer perceptron artificial neural networks. First, principal component analysis was performed on all candidate features to identify the top 10 linearly uncorrelated variables with the largest variance. This was done in an effort to simplify, as well as mitigate, overfitting of the model to the training data thereby maximizing applicability to other populations. The network was composed of three layers: an input layer consisting of the 10 principal components identified above, a hidden layer with five nodes, and an output layer producing a committee vote discriminating two possible outcomes (development of wound specific HO—"yes" or "no"). We then performed internal validation using leave-one-out cross validation methods. Finally, we compared each model using Decision Curve Analysis (DCA), a technique that weighs the clinical consequence of "wrong answers" (false positives and false negatives) generated by the models. In this fashion "net benefit," defined as patients who duly receive primary prophylaxis after appropriate risk stratification, can be calculated and plotted Vs. the threshold probability. Simply stated, the threshold probability of developing HO is the probability in which a surgeon is indecisive about whether to offer

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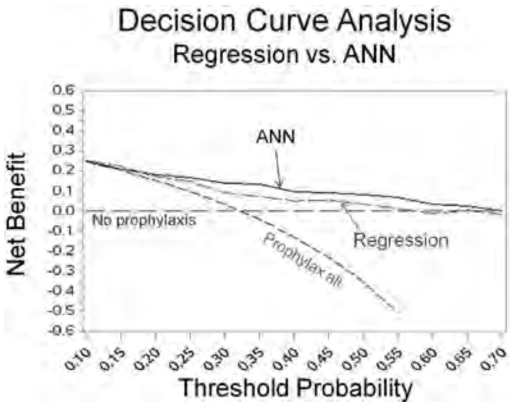
primary prophylaxis and is related to how he/she weighs the consequences of overtreating or undertreating the patient. This is done in an effort to determine which model, if any, may be best suited for clinical use and is independent of the manner of primary prophylaxis.

Results: The LR model identified a 2 gene signature (BMP4, GDF3) that successfully estimated the likelihood of eventual wound-specific HO formation. The ANN, however, identified an 8 gene signature (EGR1, CX3CL1, SMAD6, FADD, TGFB2, CCL11, CXCL11, HMGB1) that also successfully estimated the likelihood of eventual wound-specific HO development. On internal validation, the area under the Receiver Operating Characteristic (ROC) curve was 0.71 for the LR model compared to 0.78 for the ANN model. Decision Curve Analysis revealed the ANN model resulted in a higher net benefit (y-axis), when compared to the LR model (figure 1) across a broad range of threshold probabilities (x-axis).



Discussion: Heterotopic Ossification formation in blast-injured combat casualties may be the single most important barrier to meaningful functional mobility, independence, and return to active duty. There are currently no methods to risk-stratify individual wounds to guide local and/or systemic means of primary prophylaxis. Using gene transcript signatures, we developed a model that is sufficiently accurate to estimate the likelihood of wound specific HO formation at a time thought to be amenable to primary prophylaxis. Though these early results are encouraging, prospective validation is required (and is currently underway) prior to widespread clinical use.

Significance: We seek to provide personalized care of blast-injured combat casualties, particularly amputees. The ANN model developed in this project may help risk stratify patients to receive existing means of primary prophylaxis and also help guide clinical trials evaluating future novel local and systemic therapies. With early detection and selective prophylaxis, we may ultimately reduce the number patients who develop symptomatic HO and remove this barrier to functional mobility, independence and return to active duty.

Acknowledgements: Frederick Gage; Meng Shi, MSPH; Emily Ludwig, BS; Stacia Moreno, BS; Diana Golden, BS; Tala Ghadimi, BS; Felipe Lisboa, MD.

See pages 91 - 132 for financial disclosure information.


WHAT WOULD YOU DO
if a runaway car smashed
your plans to walk down the aisle?
Ari Steinfeld embraced the challenge.
Eight months after his limb-threatening accident, Ari's march down the aisle was a testament to what patient determination – and advanced orthopaedic surgery – can achieve. Go, Ari.
Read Ari's story and find your own inspiration at
ANationInMotion.org
FIGHT FOR YOUR MOBILITY
OTA ORTHOPAEDIC —TRAUMA— ASSOCIATION
AAOS AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

PSA

Dear Colleagues,

I am reaching out to ask for your support of the OTA Research Grant Program through a research donation. As you know, the OTA Research Grant program is key to the success of our mission, and without support from BOTH industry and our members, this program cannot continue to exist. I am pleased to let you know that each member of the OTA Board of Directors has pledged a donation to this year's campaign – we hope we can count on your contribution too.I would like to thank those who have already contributed this year – your support is greatly appreciated!

NEW this year, the OTA will introduce an OTA Legacy Society, for those who have contributed $10,000 and greater during their lifetime giving. It is an honor to announce our first OTA Legacy Society members:

James C. Binski, MD
William R. Creevy, MD
Florida Orthopaedic Institute, Tampa, Florida
Orthopaedic Specialists of North America, Phoenix, AZ
Andrew H. Schmidt, MD
Marc F. Swiontkowski, MD
David C. Templeman, MD
Paul Tornetta, III, MD

DONATE TO THE OTA - WAYS TO DONATE

1. Login to your Member Account to Donate directly to the OTA.
2. Call the OTA office and speak to a staff member: 847-698-1631
3. OTA Donation Form - Print and fax (847-823-0536) or mail to the staff office.
4. OREF Donation Form

*** **100% of OTA member research fund donations will go towards funding 2014 OTA-approved research studies** ***

Why contribute? Your help is needed to continue to fund the numerous outstanding OTA research efforts which include:

- Increasing the quality of patient care through multi-center studies
- Providing answers and advancement to key questions in orthopaedic trauma
- Providing orthopaedic trauma research funding to academic centers, research investigators, and residents
- Supporting the research careers and aspirations of young scientists
- Formulating and improving high standards for orthopaedic trauma call procedures
- Providing long term functional outcome and metrics investigations

The OTA has always been a leader in the advancement of orthopaedic trauma care through high quality research, which has been funded since 1990. Because of the importance of this activity, and the success we as a society have had, we urge you to consider making a contribution. This ongoing effort will allow us to maximize the funding directed to trauma related research.

Sincerely,

Andrew Schmidt

Andrew H Schmidt, MD
OTA President

ORTHOPAEDIC
—TRAUMA—
ASSOCIATION

RESEARCH FUND DONATIONS

Contribution Levels:

❑	$ ________	**Sponsors Award**	$5,000 - $24,999
❑	$ ________	**Members Award**	$1,000 - $4,999
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Phone: ________________ E-mail address: ________________

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❑ MasterCard ❑ Visa ❑ AMEX

Cardholder Name: ________________________________

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Expiration: __________ Signature: ________________________

Total Amount: ________________

OTA Memorial Fund

Memorial donations will be credited to the OTA "Best Resident/Fellow Podium Presentation/Poster Award."

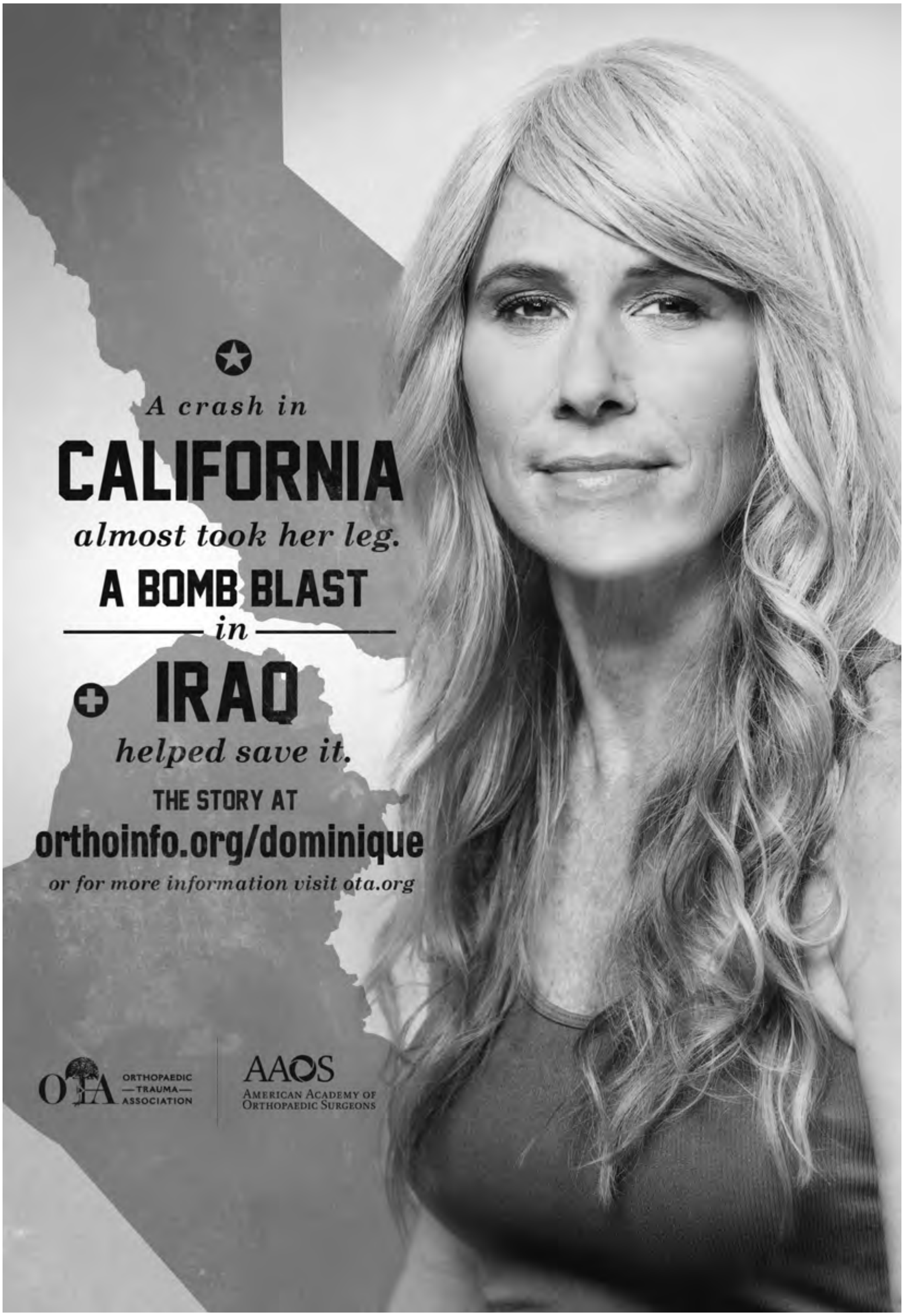
❑ $ __________ In memory of ______________________ .

Please return to:

Orthopaedic Trauma Association
Attn: OTA Research Fund
6300 N. River Road, Suite 727
Rosemont, IL 60018-4226 USA

Phone: 847-698-1631

RESEARCH FUND


A crash in
CALIFORNIA
almost took her leg.
A BOMB BLAST
in
IRAQ
helped save it.
THE STORY AT
orthoinfo.org/dominique
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OTA ORTHOPAEDIC TRAUMA ASSOCIATION
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PSA

Mission Statement

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

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

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

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 29th 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 activityfor a maximum of **18.5** ***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 29th 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 **18.5** ***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 29th 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 29th 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 29th 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;
- 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.

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.

∆ 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.

OTA MANDATORY DISCLOSURE POLICY FOR GOVERNANCE GROUPS AND CONTINUING MEDICAL EDUCATION CONTRIBUTORS

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 disclosure 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.

Orthopaedic Trauma Association
ANTITRUST POLICY
(Adopted July 2012)

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 Nots

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.

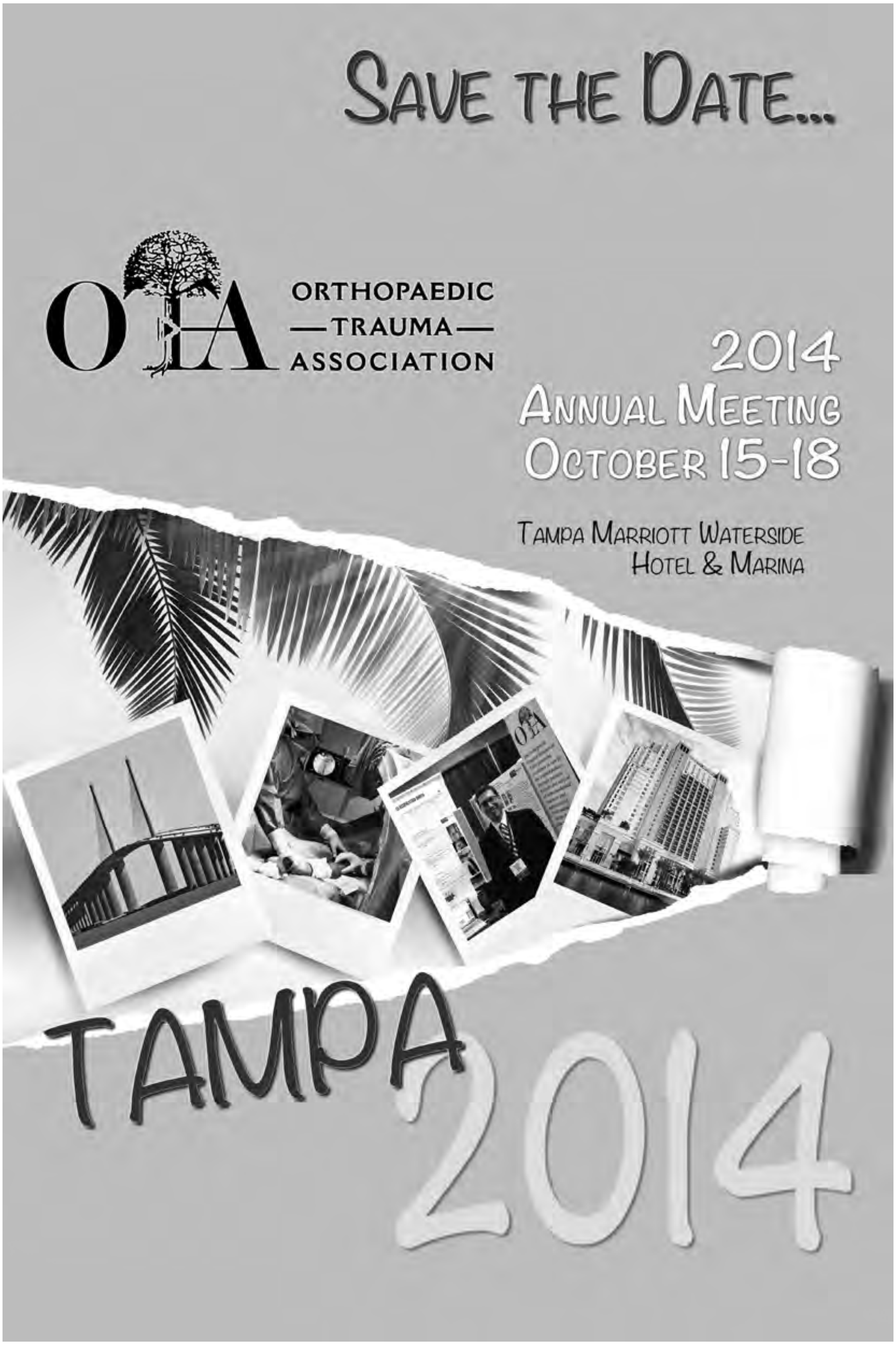
Special Guidelines for Collecting and Distributing Information

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.


2014
ORTHOPAEDIC
—TRAUMA—
ASSOCIATION
Specialty Day Meeting
March 15, 2014
Morial Convention Center – Theater C
New Orleans, Louisiana, USA
Planning Committee:
Andrew H. Schmidt, MD, President;
Joseph Borrelli, Jr., MD; Lisa K. Cannada, MD;
Christopher Finkemeier, MD; Thomas F. Higgins, MD;
Ross K. Leighton, MD; Paul Tornetta, III, MD
and Heather A. Vallier, MD
♦ Common Orthopaedic Trauma Problems: Tips, Tricks & Evidence
♦ Osteoporosis: What Is It? Who Should Treat It? And How?
♦ Trauma Techniques: Top Videos
♦ Bovill Award Presentation
♦ Annual Meeting Highlights: Ten Papers You Should Know About
♦ Trauma Jeopardy
♦ Distal Radius/Forearm Reconstruction
♦ Complex Forearm/Elbow Fractures
♦ Combined Upper Extremity Cases
Combined Session with the
American Society for Surgery of the Hand
La Place du Marché Francais
French Market Place


SAVE THE DATE...
OTA
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2014
ANNUAL MEETING
OCTOBER 15-18
TAMPA MARRIOTT WATERSIDE
HOTEL & MARINA
TAMPA
2014