ORTHOPAEDIC TRAUMA ASSOCIATION

9400 West Higgins Road, Suite 305
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Phone: (847) 698-1631
FAX: (847) 430-5140
E-mail: ota@ota.org

Theodore Miclau III, MD

Welcome to the Orthopaedic Trauma Association's (OTA) 31st Annual Meeting!

The Program Committee, under the leadership of Bob O'Toole, has created an outstanding program that includes cutting edge clinical and basic research from around the world. Each attendee can benefit from this year's Annual Meeting in some way, and I encourage you to carefully review the program and select a track that best suits your needs. Additionally, the Annual Meeting will offer an unprecedented number of opportunities to network and interact with friends and colleagues. There are social events every evening: the international reception on Wednesday, the poolside welcome reception on Thursday, and "suds and science" guided poster tours and beer and wine in the exhibit hall on Friday. Please also join me in extending a special welcome to our guest nation attendees from Germany, international attendees, and SIGN scholars from Nepal.

Finally, I want to thank all of our members who have contributed to this year's fantastic program, including the many committee members, presenters, faculty, and other volunteers. Of course, none of this would be possible without our very dedicated, professional staff.

Thank you for your support of the OTA, I hope you enjoy the meeting and your time in San Diego.

Sincerely,

Theodore Miclau, III, MD
President, Orthopaedic Trauma Association

Welcome

Find a Surgeon

OTA Membership Directory available at www.ota.org.
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Orthopaedic Trauma Association
9400 W. Higgins Road, Suite 305
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Home Page: www.ota.org

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SCIENTIFIC POSTERS *Grand Hall ABCD*
Lobby Level

Open: Thursday 2:30 pm – Saturday 1:30 pm

TECHNICAL EXHIBITS *Grand Hall ABCD*
Lobby Level

(See complete listing on pages 551 - 552)

Open:	Thursday	2:30 pm	-	5:00 pm
	Friday	9:00 am	-	5:45 pm
	Saturday	9:00 am	-	1:00 pm

SPEAKER READY ROOM *Show Office 6*
2nd Floor, Seaport Tower

4:00 pm - 6:00 pm – Tuesday
Open 6:00 am - 6:30 pm – Wednesday thru Saturday.

OTA VIDEO THEATER *Seaport Foyer*

Open 6:30 am - 5:00 pm – Wednesday thru Saturday.

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

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.

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(as of August, 2015)

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Thanks

*Memorial Donations: In memory of Dosch Macleod[1]; In memory of Dr. Jim Carr[2]; In memory of Josephine Bovill[3]

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2015 Basic Science Focus Forum

Wednesday, October 7, 2015

(Seaport FG – 2nd Floor, Seaport Tower)

6:00 am **Speaker Ready Room**
(*Show Office 6 – 2nd Floor, Seaport Tower)*

6:30 am **Registration**

Continental Breakfast
(Outside Meeting Room)

7:30 am **Introduction**
Edward J. Harvey, MD, Program Chair

7:35 – 8:45 am **SYMPOSIUM 1: MANAGEMENT OF POLYTRAUMATIZED PATIENTS WITH SEVERE WOUNDS**

Moderators: *Todd O McKinley, MD*
Timothy Billiar, MD

7:35 am **Measuring Patient-Specific Mechanical and Ischemic Tissue Injury in Multiply Injured Patients**
Greg E Gaski, MD

7:55 am **Restoring Functional Muscle in Severe Wounds with Volumetric Muscle Loss**
Benjamin Corona, PhD

8:15 am **Computational Biologic Approaches to Understanding Clinical Outcomes in Multiply Injured Patients**
Yoram Vodovotz, PhD

8:35 am Discussion

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

See pages 47 - 108 for financial disclosure information.

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.

8:45 – 9:24 am

PAPER SESSION 1: BIOMECHANICALLY-DIRECTED FIXATION

Moderators: *Todd McKinley, MD*
Timothy Billiar, MD

8:45 am	**Overview** *Timothy Billiar, MD*
8:50 am (p. 109) PAPER #1	**Cytokines as Predictors of Multiple Organ Dysfunction Syndrome of Polytrauma Patients – Osteoprotegerin and Lipocalin-2 Better than Interleukin-6?** ***Marcel Winkelmann, MD***; *Henning Peters; Christian Macke, MD; Philipp Mommsen, MD; Christian Zeckey, MD; Christian Schröter, MD; Christian Krettek, MD; Claudia Neunaber*
8:56 am (p. 110) PAPER #2	**A Severe Hemorrhagic Shock Leads to a Delayed Fracture Healing and Biomechanical Instability in a Murine Model** ***Katrin Bundkirchen, MS***; *Luisa Schäck, MD; Sandra Noack, MD; Christian Krettek, MD; Claudia Neunaber*
9:02 am (p. 112) PAPER #3	**Vancomycin and Imipenem Release from Nails Covered with Antibiotic-loaded Acrylic Cement: Pharmacokinetic Study** ***Jorge Barla, MD***; *Luciano Rossi, MD; Carlos Sancineto, MD*
9:08 am (p. 113) PAPER #4	**Elution Characteristics of PMMA Bone Cement IM Spacers Impregnated with Vancomycin and Tobramycin** ***Andrew Patton, MD***; *Brandon Perez, MD; William Buford, PhD*
9:14 am	Discussion
9:24 am	Break

See pages 47 - 108 for financial disclosure information.

9:45 – 10:50 am SYMPOSIUM 2: CRITICAL SIZE BONE DEFECTS: IS THERE A CONSENSUS IN 2015 FOR DIAGNOSIS AND TREATMENT?

Moderators: *Aaron Nauth, MD*
J Tracy Watson, MD

9:45 am	**Size Matters: Defining "Critical" in Bone Defect Size** *Emil H Schemitsch, MD*
10:00 am	**Induced Membrane Techniques (Masquelet) for Bone Defect Management** *Brent L Norris, MD*
10:15 am	**The Role of Biologics in Bone Defect Management** *J Tracy Watson, MD*
10:30 am	**Infected Bone Defects: State of the Art Treatment** *Aaron Nauth, MD*
10:45 am	Discussion

10:50 – 11:35 am PAPER SESSION 2: CRITICAL SIZE BONE DEFECTS

Moderators: *Aaron Nauth, MD*
J Tracy Watson, MD

10:50 am	**Overview** *Aaron Nauth, MD*
10:55 am (p. 114) PAPER #5	**Effect of External Beam Irradiation on the Pathway of Bone Fracture Healing** ***Yongren Wu, PhD****; Evan Hanna, MD; Daniel Mcdonald, MS; Kenneth Vanek, PhD; Hai Yao, PhD; Vincent Pellegrini, MD*
11:01 am (p. 116) PAPER #6	**Novel PTH Based Bone Graft Substitute for Treatment of Fractures: Results from a Large Ovine Tibial Plateau Defects Study** ***Jason Schense, PhD****; Brigitte von Rechenberg, DVM; Martin Stauber, PhD; Stephen Ferguson, Prof PhD*
11:07 am (p. 118) PAPER #7	**Pharmaceutical and Genetic Depletion of Sclerotin and the Effect on Fracture Healing** ***Mohammad Alzahrani, MD, MSc****; Reggie Hamdy, MB, MSc (Ortho.), FRCS(C)*

Basic Science Focus Forum – WEDNESDAY, OCTOBER 7, 2015

11:13 am
(p. 121)
PAPER #8

Comparative Analysis of Thrombopoietin (TPO), a Novel Agent to Heal Segmental Bone Defects, with Bone Morphogenetic Protein-2 (BMP-2): A Hypothesis Generating Transcriptomic Study
Nabarun Chakraborty, MS; MBA; ***Rasha Hammamieh, PhD****; Duncan Donohue, PhD; Paul Childress, PhD; Todd McKinley, MD; Benjamin Corona, PhD; Tien-Min Chu, DDS; PhD; Melissa Kacena, PhD*

11:19 am
(p. 124)
PAPER #9

BMP-2 Increases Survival of Mesenchymal Stem Cells and Fracture Healing when Deployed in Photopolymerizable Hydrogels
Motasem Refaat, MD*; Nina Vollmer, PhD; Steve Ho, BS; Oju Jeon, PhD; Eben Alsberg, PhD; Kent Leach, PhD; Mark Lee, MD*

11:25 am — Discussion

11:35 am
12:30 pm — Lunch

12:30 – 1:40 pm

SYMPOSIUM 3: ABSOLUTE VERSUS RELATIVE FIXATION

Moderators: *Joseph Borrelli Jr, MD*
Brent L Norris, MD

12:30 pm — **Plates: Alternative Fixation Methods and Their Influence on Fracture Healing**
Gerald Lang, MD

12:45 pm — **IM Nails are the Mainstay of Diaphyseal and Metaphyseal? Fracture Fixation: And Why?**
Thomas A (Toney) Russell, MD

1:00 pm — **Pros and Cons of Plates and Screws in Osteoporotic Bone**
David Rothberg, MD

1:15 pm — **Periprosthetic Fracture Fixation: To Graft or Not to Graft?**
William M Ricci, MD

1:30 pm — Discussion

See pages 47 - 108 for financial disclosure information.

1:40 – 2:19 pm PAPER SESSION 3: ABSOLUTE VERSUS RELATIVE FRACTURE FIXATION

Moderators: *Joseph Borrelli Jr, MD*
Brent L Norris MD

1:40 pm	**Overview** *Joseph Borrelli Jr, MD*
1:45 pm (p. 126) PAPER #10	**Controlled Axial Dynamization with a Novel Active Locking Plate can Deliver Faster and Stronger Healing** ***Michael Bottlang, PhD****; Stanley Tsai, MS; Anika Drechsler, BS; Brigitte von Rechenberg, DVM; Manuel Asch, BS; Daniel Fitzpatrick, MS, MD; Peter Augat, PhD; Steven Madey, MD*
1:51 pm (p. 128) PAPER #11	**A Biomechanical Comparison of Standard versus Far Cortical Locking Screws in a Periprosthetic Distal Femur Fracture** ***Kimberly Jacobsen, MD****; Gary Bledsoe, PhD; Heidi Israel, PhD, RN; Jeffrey Whiting, MD; Lisa Cannada, MD*
1:57 pm (p. 129) PAPER #12	**In Vivo Correlation of RUST Scoring with Biomechanical Strength of Nailed Tibia Fractures: Can We Finally Define Union Radiographically?** *Paul Tornetta III, MD;* ***Jody Litrenta, MD****; William Ricci, MD; Roy Sanders, MD; Robert O'Toole, MD; Henry Faber, MS; Jason Nascone, MD*
2:03 pm (p. 131) PAPER #13	**The Biomechanical Advantage of Locked versus Non-locked Symphyseal Plating of Unstable Pelvic Ring Injuries** ***Ryan Godinsky, MD****; Gregory Vrabec, MD; Loredana Guseila, BS; Danielle Filipkowski, MS; John Elias, PhD*
2:09 pm	Discussion
2:19 pm	Break

2:40 – 3:45 pm SYMPOSIUM 4: BIOMECHANICAL - HOT TOPICS 2015

Moderators: *Emil H Schemitsch, MD*
Michael Bottlang, PhD

2:40 pm **Proximal Humerus Fractures: Using Biomechanics to Reduce Failure of Locked Implants**
Pierre Guy, MD

2:48 pm **Femoral Neck Fracture Fixation: What is the Rationale for Implant Choice?**
Gerard P Slobogean, MD

2:56 pm **Nailing Unstable Intertrochanteric Fractures: Biomechanical Evidence for Improved Proximal Fixation**
Steven A Olson, MD

3:04 pm **Periprosthetic Distal Femur Fractures: Nail or Plate?**
Emil H Schemitsch, MD

3:12 pm **Syndesmotic Injuries: How Flexible Should the Fixation Be?**
David W Sanders, MD

3:20 pm **Talar Neck Fractures: Is Standard Screw Fixation Adequate?**
Timothy O White, MD

3:28 pm Discussion

3:45 – 4:50 pm PAPER SESSION 4: BIOMECHANICS

Moderators: *Emil H Schemitsch, MD*
Michael Bottlang, PhD

3:45 pm **Overview**
Emil H Schemitsch, MD

3:50 pm (p. 132) PAPER #14
The Effect of Varying Tension of a Suture Button Construct in Fixation of the Tibiofibular Syndesmosis: Evaluation Using Stress Computed Tomography
John Morellato, MBBS (Hons); *Hakim Louati, MSc; Andrew Bodrogi, MD; Andrew Stewart; MD; Steven Papp, MD, FRCPC; Allan Liew, MD, FRCSC; Wade Gofton, MD, FRCPC*

3:56 pm (p. 134) PAPER #15
Anatomic Ligament Repair Restores Ankle and Syndesmotic Rotational Stability as Much as Syndesmotic Screw Fixation
Patrick Schottel, MD; Josh Baxter, PhD; Susannah Gilbert, MS; ***Matthew Garner, MD***; *Dean Lorich, MD*

See pages 47 - 108 for financial disclosure information.

4:02 pm (p. 136) PAPER #16	**Initial Stiffness of Bicortical Locked Screw versus Unicortical Locked Screw and Graft-Cable Fixation of Comminuted Vancouver C Periprosthetic Fractures: A Biomechanical Study** ***Michael Beebe, MD****; David Hulet, BS; Casey Whale, BS; Sean Tagge, BS; Jeremy Gililland, MD; Erik Kubiak, MD*
4:08 pm	Discussion
4:18 pm (p. 138) PAPER #17	**Comparison of Three Methods for Maintaining Inter-fragmentary Compression after Fracture Fixation** ***Brigham Au, MD****; John Groundland, MD; Brandon Santoni, PhD; Kyle Stoops, MD; H Claude Sagi, MD*
4:24 pm (p. 139) PAPER #18	**Periprosthetic Supracondylar Femoral Fractures Following Knee Arthroplasty: A Biomechanical Comparison of Four Methods of Treatment** *Tatu Mäkinen, MD, PhD; Herman Dhotar, MD, FRCSC;* ***Simcha Fichman, MD****; Matthew Gunton, MD, FRCSC; Mitchell Woodside, MSc; Oleg Safir, MD, MEd, FRCSC; David Backstein, MD, MEd, FRCSC; Thomas Willett, PhD; Paul Kuzyk, MD, MASc, FRCSC*
4:30 pm (p. 141) PAPER #19	**Axial and Rotational Malreduction (Golf Club Deformity) in Distal Femur Fractures** ***Jason Lowe, MD****; Willard Moore, MD; Ali Alhandi, MBBS; David Kaimrajh, MS; Edward Milne, BSc; Loren Latta, PhD*
4:36 pm	Discussion
4:50 pm	ADJOURN

2015 Basic Science Focus Forum

Thursday, October 8, 2015

(Seaport FG – 2nd Floor, Seaport Tower)

6:00 am	**Speaker Ready Room** (*Show Office 6 – 2nd Floor, Seaport Tower)*
6:30 am	**Registration** **Continental Breakfast** *(Outside Meeting Room)*
7:25 am	**Introduction** *Edward J. Harvey, MD, Program Chair*

7:30 – 8:20 am

SYMPOSIUM 5: WHAT'S IMPORTANT BESIDES GETTING THE BONE TO HEAL?

Moderators: *Brett D Crist, MD*
Mark A Lee, MD

7:30 am	**What to Do When the Articular Cartilage Doesn't Heal or Can't Be Reconstructed?** *James P Stannard, MD*
7:40 am	**Periarticular Knee Fractures: Ligamentous Stability Affects Success** *William Harvin, MD*
7:50 am	**Fractures Don't Heal without Soft Tissue Coverage: Understanding the Soft Tissue Reconstructive Ladder** *Michael J Gardner, MD*
8:00 am	**Muscular Recovery: How Much is Lost with Injury?** *Thomas F Higgins, MD*
8:10 am	Discussion

See pages 47 - 108 for financial disclosure information.

8:20 – 9:22 am

PAPER SESSION 5: BESIDES BONE HEALING

Moderators: *Brett D Crist, MD*
Mark A Lee, MD

8:20 am	**Overview**
8:25 am (p. 143) PAPER #20	**Autologous Minced Muscle Treatment of Volumetric Muscle Loss Improves Neuromuscular Strength** *Catherine Ward, PhD; Jennifer McDaniel, PhD; Joseph Wenke, PhD;* ***Benjamin Corona, PhD***
8:31 am (p. 145) PAPER #21	**Comparison Between Supra-patellar and Para-patellar Approach for Proximal Tibia Fractures: Cadaveric Study** ***Rodolfo Zamora, MD****; Adam Short, MD; Craig Wright, MD; David Seligson, MD*
8:37 am (p. 146) PAPER #22	**Blind Area of Reverse-L Posteromedial Approach Compare with Posterolateral Approach for Posterolateral Tibial Plateau Fractures: A Cadaveric Study** ***Wich Orapiriyakul, MD****; Theerachai Apivatthakakul, MD*
8:43 am (p. 148) PAPER #23	**The Safety and Feasibility of Minimally Invasive Plate Osteosynthesis (MIPO) on the Medial Side of the Femur: A Cadaveric Injection Study** ***Theerachai Apivatthakakul, MD***
8:49 am	Discussion
8:54 am (p. 149) PAPER #24	**Under Pressure: The Utility of Splitting Fiberglass Casts** ***Kevin Kleis, DO****; John Schlechter, DO; Joshua Doan, MEng; Christine Farnsworth, MS; Eric Edmonds, MD*
9:00 am (p. 150) PAPER #25	**Targeted Stimulation of Retinoic Acid Receptor Signaling Mitigates the Formation of Heterotopic Ossification Formation in an Established Blast-Related Traumatic Injury Model** ***Gabriel Pavey, MD****; Ammar Qureshi, PhD; Allison Tomasino, BS; Danett Bishop, PhD; Masahiro Iwamoto, PhD; Maurizio Pacifici, PhD; Benjamin Potter, MD; Thomas Davis, PhD; Jonathan Forsberg, MD*
9:06 am (p. 152) PAPER #26	**Transforming Growth Factor-ß2 Gene Expression Early may be Predictive of the Severity of Future Development of Heterotopic Ossification** ***Ronald Goodlett, MD****; Patrick Jones, MD; Daniel Griffin, MD; Husain Bharmal, MD; Youngmi Ji, PhD; Leon Nesti, MD, PhD;*
9:12 am	Discussion
9:22 am	Break

9:40 – 10:40 am

SYMPOSIUM 6: DOES RESEARCH CHANGE PRACTICE?

Moderators: *Mohit Bhandari, MD*
Edward J Harvey, MD

9:40 am **Orthopaedic Research Funding Trends – Is Trauma Getting Its Fair Share?**
Mitchell Bernstein, MD

9:50 am **6 Clinical Research Papers That Have Influenced My Practice**
Michael T Archdeacon, MD

10:00 am **6 Clinical Research Papers That Have Influenced My Practice**
Steven R Papp, MD

10:10 am **Does Level I Evidence Mean "I Should Change my Practice?"**
Peter Giannoudis, MD

10:20 am **Are Journals the Future Source of Practice-Changing Evidence?**
Roy Sanders, MD

10:30 am Discussion

10:40 – 11:10 am

PAPER SESSION 6: NEW TECHNOLOGY AND RESEARCH

Moderators: *Edward J Harvey, MD*
Peter V Giannoudis, MD

10:40 am **Overview**

10:45 am (p. 154) PAPER #27
Repetitive Reduction Lead to Significant Elevated IL-6 Levels in Femoral Fractures: A Quantitative Analysis of a Robot-Assisted Reduction Process in a Rat Model
Katrin Bundkirchen, MS; *Ralf Westphal, MD; Thomas Goesling; MD; Christian Krettek, MD, FRACS; Philipp Haas, MD; Claudia Neunaber, MD*

10:51 am (p. 156) PAPER #28
Δ Carbon Monoxide Releasing Molecule-3 (CORM-3) Protects the Skeletal Muscle In Porcine Model of Compartment Syndrome
Aurelia Bihari, MSc; *Gediminas Cepinskas, DVM, PhD; David Sanders, MD; Abdel-Rahman Lawendy; MD, PhD, FRCSC*

10:57 am (p. 157) PAPER #29
Δ The Effect of Iron Chelators on Bioceramic Bone Graft Remodeling
Justin Drager, MDCM; *Zeeshan Sheikh, PhD; Yu Ling Zhang, MSc; Abhishek Kumar, MD; Edward Harvey, MD, MSc, FRCSC; Jake Barralet, PhD*

11:03 am Discussion

11:10 am **ADJOURN TO INDUSTRY SYMPOSIA**
(On-site Registration Available) – Boxed Lunch Available

Δ OTA Grant

See pages 47 - 108 for financial disclosure information.

ORTHOPAEDIC TRAUMA ASSOCIATION

2015 Annual Meeting

Thursday, October 8, 2015

(Seaport ABCDE – 2nd Floor, Seaport Tower)

6:00 am	**Speaker Ready Room** (*Show Office 6 – 2nd Floor, Seaport Tower)*
6:30 am	**Registration**
11:15 am	**INDUSTRY SYMPOSIA** *(On-site Registration Available)* Boxed Lunch Included
1:00 pm	**Welcome and Industry Donor Awards** (*Seaport ABCDE)* *Theodore Miclau III, MD – OTA President* *Robert V O'Toole, MD – Program Chair* *Jeffrey M Smith, MD – Local Host*

1:20 – 2:50 pm SYMPOSIUM I: ANXIOUS, ADDICTED AND ALONE: IT IS MORE THAN JUST THE X-RAYS!

Moderator: *William Obremskey, MD, MPH, MMHC* (*Seaport ABCDE)*
Faculty: *Kristin Archer, PT, PhD; Basam Attum, MD; Renan Castillo, PhD; Hassan R Mir, MD; Stephen Wegner, PhD*

1:20 pm	**The Opioid Epidemic** *Hassan R Mir, MD*
1:30 pm	**Alcohol and Nicotene Addiction and the Personal and Societal Cost of Addiction** *Basam Attum, MD*
1:40 pm	**Chronic Pain Burden and Predictors** *Kristin Archer, PT, PhD*
1:50 pm	**Incidence and Impact of Psychological Distress (PTSD and Depression) and Cognitive Dysfunction** *Renan Castillo, PhD*

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

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.

2:05 pm	**Multimodal Pain Treatment and Strategies to Improve Shared Decision-Making and Patient Engagement in Care Collaborative Care Models** *Stephen Wegner, PhD*
2:20 pm	**Referral and Management to Improve Cognitive-Behavioral and Self-Management Strategies for the Clinician** *William Obremskey, MD, MPH, MMHC*
2:35 pm	**Psychological Health** Q and A
2:50 - 3:20 pm	Refreshment Break Visit Scientific Posters & Technical Exhibits (*Grand Hall ABCD – Lobby Level)*

(Seaport ABCDE)

SCIENTIFIC PAPER SESSION 1
PROGRAM COMMITTEE HIGHLIGHT PAPERS: HIGH LEVEL RANDOMIZED CONTROLLED TRIALS

3:20 – 4:11 pm

Moderators - Michael D McKee, MD & Robert V O'Toole, MD

3:20 pm (p. 161) PAPER #30	**A Prospective, Randomized, Controlled Trial Comparing the Fibular Nail versus Standard ORIF for Fixation of Ankle Fractures in Patients Under 65 Years of Age** ***Timothy White, MD, FRCS****; Kate Bugler, Mb ChB, MRCS; Margaret McQueen, MD FRCS; Charles Court-Brown, MD*
3:26 pm (p. 162) PAPER #31	**An Equivalence Randomized Controlled Trial Comparing Close Contact Casting (CCC) with Internal Fixation Surgery for Unstable Malleolar Fractures in Patients Over 60 Years** ***Keith Willett, FRCS****; David Keene, DPhil; Robert Handley, FRCS; Elizabeth Tutton, PhD; Tim Chesser, FRCS; Ian Pallister, FRCS, MD; Dipesh Mistry, PhD; Julian Nam, MSc; Ranjit Lall, PhD; Andrew Briggs, DPhil; Sallie Lamb, DPhil*
3:32 pm	Discussion
3:37 pm (p. 163) PAPER #32	**Proximal Fracture of the Humerus: Evaluation by Randomization (ProfHER) Trial** ***Amar Rangan, FRCS****; Stephen Brealey, PhD; Helen Handoll, PhD; Ada Keding, MSc; Laura Jefferson, PhD; Belen Corbacho-Martin, MSc; Lorna Goodchild, MSc; Ling-Hsiang Chuang, PhD; Nigel Rossiter, FRCS; Catherine Hewitt, PhD; David Torgerson, PhD*

See pages 47 - 108 for financial disclosure information.

3:43 pm (p. 166) PAPER #33	**A Multicentre RCT Comparing the InterTAN Device Versus the Sliding Hip Screw in the Treatment of Geriatric Hip Fractures: Results Depend on Preinjury Functional Level** ***David Sanders, MD***; *Dianne Bryant, PhD; Mark MacLeod, MD; Abdel-Rahman Lawendy, MD, PhD, FRCSC; Kevin Gurr, MD; Tim Carey, MD; Christopher Bailey; Debra Bartley; Christina Tieszer, BSc, MSc; Steven Papp, MD, FRCPC; Allan Liew, MD, FRCSC; Wade Gofton, MD, FRCPC; Julia Foxall; Chad Coles, MD; Ross Leighton, MD, FRCSC, FACS; Kelly Trask, MSc; Darius Viskontas, MD; Trevor Stone, MD; Mauri Zomar; Andrew Trenholm, MD; Tracy Adams*
3:49 pm	Discussion
3:54 pm (p. 168) PAPER #34	**The Suprapatellar Variant of the Semi-Extended Surgical Approach Improves Intramedullary Nail Position Compared with the Conventional Medial Parapatellar Surgical Approach** ***Alan Johnstone, MD***; *Christopher Munro, MD; Pedro Caba, MD; Ismael Escriba, MD; Daren Forward, MD; Markus Graf, MD*
4:00 pm (p. 169) PAPER #35	**Low Intensity Pulsed Ultrasound in Acute Tibial Shaft Fractures Treated with IM Nails: The Results of the TRUST Trial** ***Paul Tornetta, MD***; *Jason Busse, DC, PhD/Assistant Prof; Mohit Bhandari, MD, FRCSC, PhD; Thomas Einhorn, MD; Emil H Schemitsch, MD; James Heckman, MD; Kwok-Sui Leong, MD; Diane Heels-Ansdell, MSc; Sun Kallyth, PhD; Gordon Guyatt, MD*
4:06 pm	Discussion

SYMPOSIUM II: RESULTS OF THE FLOW STUDY: A MULTI-NATIONAL, RANDOMIZED TRIAL EVALUATING IRRIGATING SOLUTIONS AND PRESSURES IN PATIENTS WITH OPEN FRACTURES

4:11 – 4:30 pm

(p. 171) Introduction: *Robert V O'Toole, MD* (*Seaport ABCDE)*
Moderator: *Mohit Bhandari, MD, PhD*

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.

THURSDAY, OCTOBER 8, 2015

4:30 pm – 5:00 pm

President's Message

(General Session Room - Seaport ABCDE
2nd Floor, Seaport Tower)

"The $500 Check"

Theodore Miclau III, MD
OTA President

Introduction: Ronald W. Lindsey, MD

5:00 pm – 6:00 pm **OTA BUSINESS MEETING**
(OTA Members Only) *(General Session Room - Seaport ABCDE – 2nd Floor)*

6:00 pm – 8:00 pm **WELCOME RECEPTION**
(Manchester Grand Hyatt Pool Deck – 4th Floor)

Join your colleagues for cocktails and a generous assortment of hors d'oeuvres while taking in the magnificent views of downtown, San Diego Bay and the Pacific Ocean from the pool deck of the Manchester Grand Hyatt.

See pages 47 - 108 for financial disclosure information.

ORTHOPAEDIC TRAUMA ASSOCIATION

2015 Annual Meeting

Friday, October 9, 2015

(Seaport ABCDE – 2nd Floor, Seaport Tower)

6:00 am **Speaker Ready Room**
(*Show Office 6 – 2nd Floor, Seaport Tower)*

6:15 am **Registration**

6:30 am **Scientific Posters** (Technical Exhibits Open at 9:00 am)
(*Grand Hall ABCD – Lobby Level)*

Continental Breakfast
(Outside Breakout Session Rooms)

6:30 am - 7:30 am **Concurrent Breakout Sessions –** Seating available first come, first-served.
Skills Labs
Case Presentations/Mini Symposium

6:30 – 7:30 am **SKILLS LABS** ***No Tickets Required***

(SL1) **SIGN Fracture Care International** *(Coronado A – 4th Flr, Harbor Tower)*
Lab Leader: *Lewis G. Zirkle Jr, MD*
Faculty: *Anthony Brown, MD; Richard Evan Gellman, MD; Thomas F Higgins, MD; Aung Htay, MD; Bhaskar Raj Pant, MD; Saju Pradhan, MD; Robert S. Schultz, MD; Carla Smith, MD; Frederic B Wilson, MD* and *Patrick Yoon*

(SL2) **Periprosthetic Fracture (Femur)** *(Coronado E – 4th Flr, Harbor Tower)*
Lab Leader: *Erik Kubiak, MD*
Faculty: *Eric W Fulkerson, MD; Frank A Liporace, MD; William Min, MD* and *Hassan R Mir, MD*

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.

6:30 – 7:30 am **CASE PRESENTATIONS/MINI SYMPOSIUM** ***No Tickets Required***

Periarticular Fractures of the Tibia: The Case for Going Prone Case Presentation *(Seaport F – 2nd Flr, Seaport Tower)*
Moderator: *Lisa K Cannada, MD*
Faculty: *Stephen Kottmeier, MD* and *J Tracy Watson, MD*

Treatment Strategies for Tibial Plateau Fractures Case Presentation *(Seaport G – 2nd Flr, Seaport Tower)*
Moderator: *Marcus F Sciadini, MD*
Faculty: *Michael T Archdeacon, MD; Stephen H Sims, MD; Nirmal C Tejwani, MD* and *Philip R Wolinsky, MD*

Pelvis and Acetabulum Fractures Case Presentation *(Seaport ABCDE – 2nd Flr, Seaport Tower)*
Moderator: *Paul Tornetta III, MD*
Faculty: *Robert V O'Toole, MD; Robert F Ostrum, MD; H Claude Sagi, MD* and *Jodi Siegel, MD*

Don't Be Scared! Evaluation and Management of Complex Pediatric Elbow Fractures – Mini Symposium *(Seaport H – 2nd Flr, Seaport Tower)*
Moderator: *David A Podeszwa, MD*
Faculty: *Christine A Ho, MD; Anthony I Riccio, MD* and *R Lane Wimberly, MD*

7:45 am - 9:30 am **Concurrent Sessions**
(General Session and Mini Symposia Breakouts run concurrently.)
Mini-Symposia (8:00 am - 9:30 am)
Scientific Paper Session 2: Tibia / Knee

(Seaport ABCDE)

7:45 – 9:24 am

SCIENTIFIC PAPER SESSION 2
TIBIA / KNEE

Moderators - Michael D McKee, MD & Raymond R White, MD

7:45 am
(p. 172)
PAPER #37

Can Electromagnetic Navigation for Distal Locking of Intramedullary Nail Reduce Procedure Time and Radiation Exposure?
Takashi Miaymoto, MD; *Shu Obara, MD; Shuji Isefuku, MD; Takeshi Doi, MD; Atsuhiko Mogami, MD; Yoshihisa Anraku, MD; Kensuke Sakai, MD; Masayuki Ito, MD; Ryouichi Kawakami, MD; Masahiro Shirahama, MD; Mitustoshi Sagara, MD; Tomohiro Yasuda, MD; Haruyosi Yamashita, MD*

7:51 am
(p. 174)
PAPER #38

Suprapatellar Intramedullary Nail Technique Lowers Rate of Malalignment of Distal Tibia Fractures
Frank Avilucea, MD; *Kostas Triantafillou, MD; Paul Whiting, MD; Ed Perez, MD; Hassan Mir, MD, MBA*

7:57 am
(p. 175)
PAPER #39

Clinical and Functional Results of 116 Patients with Knee Dislocations
Nicholas Scarcella, BS; *Stephen Bowen; Heather Vallier, MD*

See pages 47 - 108 for financial disclosure information.

8:03 am	Discussion
8:08 am (p. 176) PAPER #40	**Superior Outcomes after Operative Fixation of Patella Fractures using a Novel Cage Plate Construct: A Prospective Cohort Study** ***Stephen Warner, MD, PhD****; Lionel Lazaro, MD; Ryan Thacher, BA; Gina Sauro, PT, DPT; Matthew Garner, MD; David Helfet, MD; Dean Lorich, MD*
8:14 am (p. 178) PAPER #41	**Function and Knee Range of Motion Plateau 6 Months Following Tibial Plateau Fractures** ***Anthony Christiano, BA****; Christian Pean, MS; Sanjit Konda, MD; Kenneth A Egol, MD*
8:20 am (p. 179) PAPER #42	**Is Early Total Care of Bicondylar Tibial Plateau Fractures Safe?** ***Florence Unno, MD****; Kelly Lefaivre, MD; Georg Osterhoff, MD; Henry Broekhuyse, MD; Pierre Guy, MD; Peter O'Brien, MD, FRCSC*
8:26 am	Discussion
8:31 am (p. 181) PAPER #43	**A Novel PTH based Bone Graft Substitute Demonstrates Noninferiority to Autograft in a Large Phase IIb Study of Tibial Plateau Fractures** ***Tom Lyon, MD****; Francisco Baixauli Garcia, MD; Andrzej Bohatyrewciz, MD; Vicente Casa de Pantoja, MD; Zoltan Detre, MD; Klaus Dresing, MD; Frederic Dubrana, MD; Peter Giannoudis, MD, FRCS, MBBS, BS; Andrzej Gorecki, MD; Tibor Gunther, MD; William Harries, MD; Peter-Michael Hax, MD; Christian Krettek, MD, FRACS; Krzysztztof Kwiatkowski, MD; Manuel Leyes Vence, MD; Zoltan Magyari, MD; Henry Mathevon, MD; Peter Messmer, MD; Khitish Mohanty, MD, FRCS; Elvira Montanez, MD; Antonio Pace, MD; Amratial Patel, MD; Stefan Piltz, MD; Anthony Pohl, MD; Angelo Rando, MD; Michael Raschke, MD; Xavier Roussignol, MD; Horst Stephan, MD; Endre Varga, MD; Jerzy Widuchowski, MD; Istvan Zagh, MD; Jason Schense, PhD*
8:37 am (p. 184) PAPER #44	**Functional and Clinical Outcomes of Nonoperatively Managed Tibial Plateau Fractures** ***Christian Pean, MS****; Anthony Christiano, BA; Sanjit Konda, MD; Roy Davidovitch, MD; Kenneth A Egol, MD*
8:43 am (p. 185) PAPER #45	**Acute in Vivo Metrics of Joint Incongruity Following Articular Fracture Predict Posttraumatic Arthritis in Mice** *Tyler Vovos, BS****; Steven A Olson, MD***
8:49 am (p. 187) PAPER #46	**Decreased Bone Density in Geriatric Patients Does Not Lead to Inferior Outcomes After Open Reduction and Internal Fixation of Tibial Plateau Fractures** ***Matthew Garner, MD****; Elizabeth Gausden, MD; Stephen Warner, MD, PhD; Andre Shaffer, MD; Dean Lorich, MD*
8:55 am	Discussion

9:00 am (p. 189) PAPER #47	**Plateau Indicators for Intervention after Operative Treatment (PIVOT) Score Identifies Patients at Risk of Poor Functional Outcome After Tibial Plateau Fracture** ***Sanjit Konda, MD***; *Arthur Manoli, BS; Roy Davidovitch, MD; Kenneth A Egol, MD*
9:06 am (p. 190) PAPER #48	**Objective Metric of Energy Absorbed in Tibial Plateau Fractures Corresponds Well to Clinician Assessment of Fracture Severity** ***Laurence Kempton, MD***; *Kevin Dibbern, BS; Donald Anderson, PhD; Saam Morshed, MD; Thomas Higgins, MD; Larry Marsh, MD; Todd McKinley, MD*
9:12 am (p. 192) PAPER #49	**The Effect of Soft Tissue Injuries on Clinical Outcomes Following Tibial Plateau Fracture Fixation** ***Stephen Warner, MD, PhD***; *Matthew Garner, MD; Patrick Schottel, MD; Peter Fabricant, MD, MPH; Ryan Thacher, BA; Michael Loftus, MD; David Helfet, MD; Dean Lorich, MD*
9:18 am	Discussion
9:24 am	Refreshment Break and Visit Scientific Posters & Technical Exhibits (*Grand Hall ABCD – Lobby Level)*
8:00 am - 9:30 am	**Concurrent Breakout Sessions** ***(Mini Symposia and General Session run concurrently.)*** Mini-Symposia Scientific Paper Session 2: Tibia / Knee

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

Critical Aspects of Orthopaedic Trauma in 2015 that Can Impact your Financial Future *(Seaport F – 2nd Flr, Seaport Tower)*
Moderator: *Peter Althausen, MD, MBA*
Faculty: *Timothy Bray, MD; Austin Hill, MD, MPH; Chris McBride, MBA; Justin Walker, MD* and *Anthony Williams ChFC, RFC, CLU*

NSAIDs and Bone Healing: Clinical Practice and Understanding the Discrepancies in the Literature *(Seaport G – 2nd Flr, Seaport Tower)*
Moderator: *Steven A Olson, MD*
Faculty: *Kamal Ajam, MD; Joseph R Hsu, MD* and *Alejandro Marquez-Lara, MD*

Educating in Fracture Surgery *(Seaport H – 2nd Flr, Seaport Tower)*
Moderator: *Samir Mehta, MD*
Faculty: *Tim Achor, MD; Jaimo Ahn, MD* and *Matthew Graves, MD*

See pages 47 - 108 for financial disclosure information.

9:55 –
11:15 am

SYMPOSIUM III: ACETABULAR FRACTURES IN PATIENTS OLDER THAN 60

Moderator: *Theodore T Manson, MD* (*Seaport ABCDE)*
Faculty: *David L Helfet MD; Robert V O'Toole MD; Adam J Starr MD*

9:55 am	**Comparitive Effectiveness of ORIF, Percutaneous Fixation and THA for the Management of Acetabular Fractures in Patients Older than 60** *Robert V O'Toole MD*
10:10 am	**Approach, Reduction and Fixation of Acetabular Fractures through the Anterior Approach** *David A Helfet MD*
10:25 am	**Techniques for the Percutaneous Reduction and Fixation of Acetabular Fractures in Older Patients** *Adam J Starr MD*
10:40 am	**ORIF plus Concomittant THA for Older Patients with Acetabular Fractures** *Theodore T Manson MD*
10:55 am	Case Review-Discussion

11:15 am –
11:45 am

Guest Nation – Germany

The OTA is honored to welcome Germany as the 2015 Guest Nation. We are pleased to have the opportunity for collaboration with our German colleagues, and a chance to recognize their contributions and achievements.

Best International Forum Paper:
Predictors of Reoperation for Adult Femoral Shaft Fractures Managed Operatively in Sub-Saharan Africa
Edmund Eliezer, MD*; Billy Haonga, MD; Saam Morshed, MD; David Shearer, MD*

Guest Nation Introduction
Theodore Miclau III, MD*, OTA President*

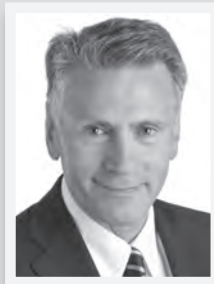
Guest Nation Presentation
Prof. Michael L. Nerlich, MD
2015 President of both the German Society for Trauma Surgery and German Society for Orthopaedics and Trauma Surgery

"The German Trauma Network Initiative - Challenges and Advantages"

Discussion

11:45 am –
12:15 pm

John Border, MD Memorial Lecturer



(General Session Room - Seaport ABCDE – 2nd Flr)

Christian Krettek, MD, FRACS, FRCSEd,
Professor and Chair Hannover School of Medicine Trauma Department Hannover, Germany

"Minimally Invasive Surgery - Past, Present, Future"

Introduction: Theodore Miclau III, MD

12:15 pm - 1:15 pm

Lunch and
Visit Scientific Posters & Technical Exhibits
(All in Grand Hall ABCD – Lobby Level)

12:15 pm – 1:15 pm

ORTHOPAEDIC TRAUMA ASSOCIATION

New Member Luncheon
(tickets required)
(America's Cup ABCD – 4th Floor)

12:15 pm – 1:15 pm

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

(Marina Room – Lobby Level)
(Exit the back of the hotel via Harbor Tower lobby level rear exit; near Sally's and Ann Marie's Coffee Shop)

Chairs: *Lisa M Truchan, MD and Alexandra Schwartz, MD*

12:30 pm – 1:15 pm **GUIDED POSTER TOURS** ***Tickets Required***

(PT1) **International** *(Grand Hall ABCD – Lobby Level)*
Guide: *Peter V Giannoudis, MD*

(PT2) **Hip, Femur, Geriatric** *(Grand Hall ABCD – Lobby Level)*
Guide: *Thomas F Higgins, MD*

See pages 47 - 108 for financial disclosure information.

1:15 pm – 2:45 pm **Concurrent Breakout Sessions –** Seating available first come, first-served.
Skills Labs
Mini Symposia

1:15 – 2:15 pm	**SKILLS LABS**	***No Tickets Required***

(SL3) **IM Nailing Proximal Tibia Fractures** *(Coronado D – 4th Flr, Harbor Tower)*
Lab Leader: *Paul Tornetta III, MD*
Faculty: *Cory A Collinge, MD; Reza Firoozabadi, MD, MA; Daniel S Horwitz, MD; Clifford Jones, MD, FACS; Erik Kubiak, MD; Brian H Mullis, MD; Hassan R Mir, MD, MBA, FACS* and *Judith A Siegel, MD*

(SL4) **Fixation of Proximal Humerus Fractures** *(Coronado E – 4th Flr, Harbor Tower)*
Lab Leader: *Andrew R Fras, MD*
Faculty: *Mark Hale, MD; Aaron M Perdue, MD; David J Polga, MD* and *MAJ Daniel J Stinner, MD*

1:15 – 2:45 pm	**MINI SYMPOSIA**	***No Tickets Required***

Pelvic Ring Disruption Decision Making: Assessment of Stability, Strategies of Fixation, and Determining What Needs To Be Fixed *(Seaport F – 2nd Flr, Seaport Tower)*
Moderator: *Jason Nascone, MD*
Faculty: *Joshua L Gary, MD; Pierre Guy, MD; Conor P Kleweno, MD; H Claude Sagi, MD* and *Adam J Starr, MD*

Developing a Successful Clinical Research Program *(Seaport G – 2nd Flr, Seaport Tower)*
Moderator: *Heather A Vallier, MD*
Faculty: *Mary Breslin, BA* and *William T Obremskey, MD*

Rib Fracture Fixation and the Surgical Management of Flail Chest Injuries: State of the Art *(Seaport H – 2nd Flr, Seaport Tower)*
Moderator: *Michael D McKee, MD*
Faculty: *Peter Althausen, MD; Niloofar Dehghan, MD; Aaron Nauth, MD; Emil H Schemitsch, MD* and *Gerard Slobogean, MD*

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(Seaport ABCDE)

SCIENTIFIC PAPER SESSION 3
GENERAL INTEREST I: PEDIATRICS / NON-UNION / SPINE / COMPARTMENT SYNDROME

1:15 – 3:05 pm

Moderators - David J Hak, MD & Cyril Mauffrey, MD

1:15 pm
(p. 194)
PAPER #50

Operative Versus Conservative Management of Displaced Tibial Shaft Fractures in Adolescents
Matthew Kinney, MD; *David Nagle, BA; Tracey Bastrom, MA; Michael Linn, MD; Alexandra Schwartz, MD; Andrew Pennock, MD*

1:21 pm
(p. 195)
PAPER #51

Fracture Classification Predicts Functional Outcomes in Supracondylar Humerus Fractures: A Prospective Study
Justin Ernat, MD; ***Anthony Riccio, MD****; Robert Wimberly, MD; David Podeszwa, MD; Christine Ho, MD*

1:27 pm
(p. 196)
PAPER #52

Factors that Predict Instability in Pediatric Diaphyseal Both Bone Forearm Fractures
Jeffrey Kutsikovich, MD; ***Christopher Hopkins, MD****; Edwin Gannon, BS; Derek Kelly, MD; Jeffrey Sawyer, MD*

1:33 pm
(p. 197)
PAPER #53

Best Trauma Paper of the 2015 POSNA Annual Meeting
Implementation of a Standardized Clinical Assessment and Management Plan (SCAMP) for Pediatric Distal Radius Fractures: Effect on Quality and Care
Donald S Bae, MD; Rachel L DiFazio, MS, RN; Marie Harris, MPH; Dionne Graham, PhD; Rose Hamershock, MA; ***Susan Mahan, MD;*** *Peter M Waters, MD*

1:39 pm
Discussion

1:44 pm
(p. 198)
PAPER #54

Factors Associated with Development of Nonunion or Delayed Healing following Open Fracture: A Prospective Cohort Study of 736 Subjects
Don Weber, MD*; Joseph Westgeest, BSc; Sukhdeep Dulai, MD, MSc; Joseph Bergman, MD; Richard Buckley, MD; Lauren Beaupre, PT, PhD*

1:50 pm
(p. 199)
PAPER #55

A Predictive Model of Tibial Shaft Fracture Nonunion at the Time of Definitive Fixation
Kevin O'Halloran, MD*; Max Coale, BA; Timothy Costales, BS; Timothy Zerhusen, BS; Renan Castillo, MD; Jason Nascone, MD; Robert O'Toole, MD*

1:56 pm
(p. 201)
PAPER #56

Prospective Prediction of Tibial and Femoral Shaft Fracture Nonunion at Four Months
Sarah Foyil, BA; Brett Schiffman, BA; Frank DiSilvio, BS; Mitchell Bernstein, MD, FRCSC; Hobie Summers, MD; ***William Lack, MD***

2:02 pm
Discussion

See pages 47 - 108 for financial disclosure information.

2:07 pm (p. 202) PAPER #57	**Ketorolac Administered in the Recovery Room for Acute Pain Management Does Not Affect Healing Rates of Femoral and Tibial Fractures** ***David Donohue, MD****; Drew Sanders, MD; Rafael Serrano-Riera, MD; Charles Jordan, MD; H Claude Sagi, MD*
2:13 pm (p. 203) PAPER #58	**Posttraumatic Tibial Defects Treated By The Ilizarov Method: Comparison of Classic Versus Integrated Technique** ***Mitchell Bernstein, MD, FRCSC****; Austin Fragomen, MD; Samir Sabharwal, BA; Jonathan Barclay, BA; S Rozbruch, MD*
2:19 pm (p. 205) PAPER #59	**Is this Autograft Worth It? The Blood Loss and Transfusion Rates Associated with RIA Bone Graft Harvest** ***Lucas Marchand, MD****; David Rothberg, MD; Erik Kubiak, MD; Thomas Higgins, MD*
2:25 pm (p. 206) PAPER #60	**Treatment of Hypovitaminosis D in an Orthopaedic Trauma Population** ***Brendan Andres****; Benjamin Childs, BS; Anna Wallace, MD; Heather Vallier, MD*
2:31 pm	Discussion
2:36 pm (p. 207) PAPER #61	**Incidence of Complications After Therapeutic Anticoagulation in the Postoperative Spine Trauma Patient** ***Brian Shiu, MD****; Elizabeth Le, MD; Timothy Costales, BS; Nicholas Caffes, BS; Ehsan Jazini, MD; Daniel Gelb, MD; Eugene Koh, MD, PhD; Bizhan Aarabi, MD; Steven Ludwig, MD*
2:42 pm (p. 208) PAPER #62	**Can Thrombelastography Predict Venous Thromboembolic Events in Patients with Spine Trauma?** ***Mark Prasarn, MD****; Zayde Radwan, MD; Prism Schneider, MD, PhD, FRCSC; Joshua Gary, MD*
2:48 pm (p. 209) PAPER #63	**Narcotic Requirements is Not Predictive of Adult Traumatic Compartment Syndrome** ***Ehsan Jazini, MD****; Ebrahim Paryavi, MD, MPH; Christine Helou, MD; Joshua Abzug, MD*
2:54 pm (p. 210) PAPER #64	**Microdialysis Detects Ischemic Change Early in the Evolution of Acute Compartment Syndrome** ***Alexander Crespo, BS****; Sanjit Konda, MD; Abraham Goch, BS; Kenneth Egol, MD*
3:00 pm	Discussion
3:05 pm	Refreshment Break and Visit Scientific Posters & Technical Exhibits (*Grand Hall ABCD – Lobby Level)*

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.

(Seaport ABCDE)

3:35 – 4:32 pm

SCIENTIFIC PAPER SESSION 4
PELVIS / ACETABULUM

Moderators - Stephen Kottmeier, MD & Paul Tornetta III, MD

3:35 pm (p. 212) PAPER #65	**Anatomic Reduction of Acetabular Fractures – When is the Best Time to Operate?** *Steven Dailey, MD;* ***Michael Archdeacon, MD****; Caleb Phillips, PhD; Joseph Radley, MD*
3:41 pm (p. 214) PAPER #66	**The Effect of Three Dimension Printing Modeling for Treating Complex Acetabular Fractures-A Randomized Prospective Study** ***Hu Wang, MD****; Kun Zhang, MD; Yan Zhuang*
3:47 pm	Discussion
3:52 pm (p. 215) PAPER #67	**Does Injury Mechanism Influence Eventual Conversion to THA After Acetabular Fractures in Geriatric Patients?** ***Aaron Johnson, MD****; Robert O'Toole, MD; Patrick Greenwell, BS; Theodore Manson, MD*
3:58 pm (p. 216) PAPER #68	**Long Term Hip Joint Survival and Clinical Results in Conservatively Treated Acetabular Fractures** ***John Clarke-Jenssen, MD****; Anette Wikerøy, MD; Ingrid Eitzen, PhD; Jan Erik Madsen, MD, PhD, Professor*
4:04 pm	Discussion
4:09 pm (p. 217) PAPER #69	**∆ Surgery for Unilateral Sacral Fractures: Are the Indications Clear?** ***Paul Tornetta, MD****; Julie Agel, ATC; Sean Nork, MD; Clifford Jones, MD, FACS; Heather Vallier, MD; Brian Mullis, MD; Zachary Roberts, MD; James Goulet, MD; Anna Miller, MD, FACS; Andrew Schmidt, MD*
4:15 pm (p. 219) PAPER #70	**Posterior Fixation in APC-2 Pelvic Ring Injuries Decreases the Rates of Anterior Plate Failure and Malunion** ***Frank Avilucea, MD****; Paul Whiting, MD; Hassan Mir, MD, MBA*
4:21 pm (p. 220) PAPER #71	**A Prospective Trial Comparing Magnetic Resonance Imaging-Detected Pelvic Ligament Injury to Displacement on Pelvic Stress Examination Under Anesthesia** ***Brendan O'Daly, MD FRCS(Tr&Orth)****; Lina Chen, MD; Derik Davis, MD; Joshua Gary, MD; Christopher Lebrun, MD; Christina Boulton, MD; Theodore Manson, MD; Jason Nascone, MD; Marcus Sciadini, MD; Michael Mulligan, MD; Robert O'Toole, MD*
4:27 pm	Discussion

∆ OTA Grant

See pages 47 - 108 for financial disclosure information.

4:30 - 5:45 pm **Concurrent Sessions**
(Mini Symposia and General Session run concurrently.)
Mini Symposia
Scientific Paper Session 5: Femur and Polytrauma

4:30 – 5:45 pm

MINI SYMPOSIA

Getting Your Fragility Fracture Program Off the Ground: A Primer for the Orthopaedic Trauma Surgeon *(Seaport F – 2nd Flr, Seaport Tower)*
Moderator: *James A Goulet, MD*
Faculty: *Kyle J Jeray, MD; Clifford B Jones, MD; Joseph M Lane, MD* and *Debra Sietsema, MD*

The Social Savvy Surgeon: Strategies to Manage Your Online Reputation and Enhance Patient Care *(Seaport G – 2nd Flr, Seaport Tower)*
Moderator: *Lisa K Cannada, MD*
Faculty: *Basil R. Besh, MD; Steven Mora; Jeffrey Smith, MD* and *Lisa Taitsman, MD*

(Seaport ABCDE)

4:32 – 5:48 pm

SCIENTIFIC PAPER SESSION 5
FEMUR AND POLYTRAUMA

Moderators - Gilbert R Ortega, MD & David H Chafey III, MD

4:32 pm
(p. 222)
PAPER #72
Fixed-angle versus Polyaxial Locking Plate Fixation Systems for Periprosthetic and/or Osteoporotic Distal Femoral Fractures
Nikolaos Kanakaris, MD, PhD*; Oghofori Obakponovwe, MRCS; Matthew Costa, MD; David Shaw, MD, MSc, FRCS; Khitish Mohanty, MD, FRCS; Peter Giannoudis, MD, FRCS, MBBS, BS*

4:38 pm
(p. 224)
PAPER #73
Δ The Effect of Knee Flexion Contracture on Outcomes of Distal Femur Fractures
Paul Tornetta, MD; ***Margaret Cooke, MD****; Kenneth Egol, MD; Clifford Jones, MD, FACS; Janos Ertl, MD; Brian Mullis, MD; Ed Perez, MD; Cory Collinge, MD; Robert Ostrum, MD; Catherine Humphrey, MD; Robert Dunbar, MD; Michael Gardner, MD; William Ricci, MD; Laura Phieffer, MD; David Teague, MD; William Ertl, MD; Christopher Born, MD; Alan Zonno, MD; Jodi A Siegel, MD; H Claude Sagi, MD; Andrew Pollak, MD; Andrew Schmidt, MD; David Templeman, MD; Stephen Sems, MD; Darin Friess, MD; Hans-Christoph Pape, MD*

4:44 pm
(p. 226)
PAPER #74
Malalignment after Minimally Invasive Plate Osteosynthesis in Distal Femoral Fractures
Joon-Woo Kim, MD, PhD*; Chang-Wug Oh, MD, PhD; Jong-Keon Oh, MD, PhD; Kyeong-Hyeon Park, MD*

Δ OTA Grant

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.

4:50 pm	Discussion
4:55 pm (p. 227) PAPER #75	**Trochanteric Entry Femoral Nails Yield Better Postoperative Femoral Version and Lower Revision Rates Than Retrograde and Piriformis Entry Nails: A Large Cohort Multivariate Regression Analysis** ***Richard Yoon, MD***; *Mark Gage, MD; David Galos, MD; Derek Donegan, MD; Frank Liporace, MD*
5:01 pm (p. 231) PAPER #76	**Sagittal Femoral Bow is Dependent on Bone Density** ***John Lee, MD, MS***; *Samuel Rosenbaum, MD; Manuel Schubert, MD; Stewart Wang, MD, PhD; James Goulet, MD*
5:07 pm (p. 232) PAPER #77	**Immediate Weight Bearing as Tolerated has Improved Outcomes Compared to Non-Weight Bearing after Intramedullary Fixation for Subtrochanteric Fractures** *Brian Miller, MD;* ***Brian P Cunningham, MD***; *Anthony Rhorer, MD; Gilbert Ortega, MD, MPH; Hrayr Basmajian, MD; Justin Roberts, MD; Kelly Jackson, NP; Saif Zaman, MD*
5:13 pm (p. 234) PAPER #78	**∆ Do We Really Understand the Patient Populations in Database Research: A Comparison of Femoral Shaft Fracture Patients in Three Commonly Used National Databases** ***Andre Samuel, BBA***; *Adam Lukasiewicz, MSc; Matthew Webb, BA; Daniel Bohl, MPH; Bryce Basques, BS; Arya Varthi, MD; Michael Leslie, DO; Jonathan Grauer, MD*
5:19 pm	Discussion
5:24 pm (p. 236) PAPER #79	**Patient-Specific Injury Profiles Predict Organ Failure in Multiply Injured Patients** *Greg Gaski, MD;* ***Travis Frantz, BS***; *Tyler McCarroll, BS; Scott Steenburg, MD; Todd McKinley, MD*
5:30 pm (p. 238) PAPER #80	**Limb Salvage Versus Transtibial Amputation: A Comparison of Functional Gait Outcomes** ***Katharine Mangan, MD***; *Trevor Kingsbury, MA; Marilynn Wyatt, MA, PT; Kevin Kuhn, MD*
5:36 pm (p. 241) PAPER #81	**Increasing Severity of the Orthopaedic Trauma Association Open Fracture Classification (OTA-OFC) Correlates with Increasing Amputation Rate: A Prospective Multicenter Study** ***Joseph Johnson, MD***; *Julie Agel, ATC; Matthew Karam, MD*
5:42 pm	Discussion
5:48 pm	Adjourn

∆ OTA Grant

See pages 47 - 108 for financial disclosure information.

5:48 - 6:45 pm

Military Reception -
(Harbor Terrace – 2nd Floor, Harbor Tower)
Hosted by the OTA Board of Directors and the OTA Military Committee
All Active Duty Military, Retired Military, and Landstuhl Distinguished Visiting Scholar participants are welcome to attend.

5:48 - 6:45 pm

Exhibit Reception
(Grand Hall ABCD – Lobby Level)
Join the OTA and our industry partners for exhibit hall happy hour in the Grand Hall.

6:00 – 6:45 pm

'SUDS AND SCIENCE' GUIDED POSTER TOURS

Tickets Required

(PT3) **Foot and Ankle** *(Grand Hall ABCD – Lobby Level)*
Guide: *Paul Tornetta III, MD*

(PT4) **Upper Extremity** *(Grand Hall ABCD – Lobby Level)*
Guide: *Michael D. McKee, MD*

ORTHOPAEDIC TRAUMA ASSOCIATION

2015 Annual Meeting

Saturday, October 10, 2015

(Seaport ABCDE – 2nd Floor, Seaport Tower)

6:00 am	**Speaker Ready Room** (*Show Office 6 – 2nd Floor, Seaport Tower)*
6:15 am	**Registration**
6:30 am	**Scientific Posters** (Technical Exhibits Open at 9:00 am) (*Grand Hall ABCD – Lobby Level)* **Continental Breakfast** *(Outside Breakout Session Rooms)*
6:30 am - 7:30 am	**Concurrent Breakout Sessions –** Seating available first come, first-served. Skills Labs Mini Symposia / Case Presentation

6:30 – 7:30 am **SKILLS LABS** ***No Tickets Required***

(SL5) **Complex Ankle Fractures: Posterior Malleolus, Syndesmosis** *(Coronado A – 4th Flr, Harbor Tower)*
Lab Leader: *John Alan Scolaro, MA, MD*
Faculty: *Timothy S Achor, MD; Jaimo Ahn, MD, PhD; Mitchell Bernstein, MD; Christiaan N Mamczak, DO; Geoffrey S Marecek, MD; Hassan R Mir, MD, MBA, FACS; Amer Jawad Mirza, MD* and *Gilbert R Ortega, MD, MPH*

(SL6) **Fixation of Intra-Articular Distal Humeral Fractures** *(Coronado D – 4th Flr, Harbor Tower)*
Lab Leader: *Michael D McKee, MD*
Faculty: *Niloofar Dehghan, MD; Kenneth A Egol, MD; Patrick David George Henry, MD, FRCSC; Kenneth J Koval, MD* and *David W Sanders, MD*

See pages 47 - 108 for financial disclosure information.

6:30 – 7:30 am **MINI SYMPOSIA/CASE PRESENTATION** ***No Tickets Required***

Proximal Humerus Fractures: Optimizing Surgical Management and Technique in 2015 Mini Symposium *(Seaport ABCDE – 2nd Flr, Seaport Tower)*
Moderator: *Emil H Schemitsch, MD*
Faculty: *Pierre Guy, MD; Dean G Lorich, MD; Michael D McKee, MD; Aaron Nauth, MD* and *David C Ring, MD*

What Could Go Wrong Did: Getting Out of Trouble Mini Symposium *(Seaport F – 2nd Flr, Seaport Tower)*
Moderator: *Lisa K Cannada, MD*
Faculty: *Clifford B Jones, MD; Matt Mormino, MD* and *Brian H Mullis, MD*

"Young" Femoral Neck Fractures – Why Do They Cause so Much Stress? Mini Symposium *(Seaport G – 2nd Flr, Seaport Tower)*
Moderator: *Brett D Crist, MD*
Faculty: *Tania Ferguson, MD; Christopher Finkemeier, MD* and *Mark A Lee, MD*

Distal Femur Fractures – Not as Easy as You Think - Case Presentation *(Seaport H – 2nd Flr, Seaport Tower)*
Moderator: *Samir Mehta, MD*
Faculty: *Timothy Achor, MD; Derek Donegan, MD* and *Hobie Summers, MD*

7:45 – 9:00 am **SYMPOSIUM IV: ELBOW TRAUMA: HOW TO IMPROVE OUTCOMES IN 2015**

Moderator: *Michael D McKee, MD* (*Seaport ABCDE)*
Faculty: *Niloofar Dehghan, MD; Kenneth A Egol, MD; Aaron Nauth, MD; David C Ring, MD; Emil H Schemitsch, MD*

7:45 am **Distal Humerus Fractures: Evidence Based Management**
Emil H Schemitsch, MD

7:55 am **Radial Head / Neck Fractures: When and How to Fix**
Kenneth A Egol, MD

8:05 am **Terrible Triad Injuries: How to Improve Outcomes**
Aaron Nauth, MD

8:15 am **Monteggia Fracture Dislocations: Timing and Techniques**
David C Ring, MD

8:25 am **Complex Injuries: The Role of Arthroplasty**
Niloofar Dehghan, MD

8:35 am **Managing Complications in Elbow Fracture Surgery**
Michael D McKee, MD

8:45 am **Cases, Questions, Discussion, Consensus**

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.

9:00 am	Refreshment Break and Visit Scientific Posters & Technical Exhibits (*Grand Hall ABCD – Lobby Level)*
9:30 am - 11:00 am	**Concurrent Sessions** ***(General Session and Mini Symposia Breakouts run concurrently.)*** Mini-Symposia Scientific Paper Session 6: Foot and Ankle

9:30 – 11:00 am

MINI SYMPOSIA

Management of Soft Tissue Defects in the Mangled Extremity A Primer for the Orthopaedic Trauma Surgeon *(Harbor B – 2nd Flr, Harbor Tower)*
Moderator: *Raymond A Pensy, MD*
Faculty: *H Michael Frisch, MD; Joseph Hsu, MD* and *Stephen J Kovach III, MD*

The Treatment of Periprosthetic Fractures in 2015: Can We Reach a Consensus? *(Harbor A – 2nd Flr, Harbor Tower)*
Moderator: *Emil H Schemitsch, MD*
Faculty: *Cory Collinge, MD; George Haidukewych, MD; Michael D McKee, MD;* and *Aaron Nauth, MD*

(Seaport ABCDE)

9:30 – 11:08 am

SCIENTIFIC PAPER SESSION 6
FOOT AND ANKLE

Moderators - Robert V OToole, MD & Thomas F Higgins, MD

9:30 am (p. 243) PAPER #82	**Long Acting Local Anesthetic in Ankle Fractures Requiring ORIF Reduces Postoperative Narcotic Use: A Randomized Trial** *Roy Davidovitch, MD;* ***Abraham Goch, BS****; Sanjit Konda, MD; Christian Pean, MS; Kenneth Egol, MD*
9:36 am (p. 244) PAPER #83	**Association between Opioid Intake and Disability after Operative Treatment of Ankle Fractures** *Abigail Finger, BA; Teun Teunis, MD; Michiel Hageman, MD; Emily Thornton, BS; Malcolm Smith, MD;* ***David Ring, MD, PhD***
9:42 am (p. 246) PAPER #84	**Incisura Morphology as a Risk Factor for Syndesmotic Malreduction** ***Steven Cherney, MD****; Amanda Spraggs-Hughes, MA; Christopher McAndrew, MD; William Ricci, MD; Michael Gardner, MD*
9:48 am	Discussion

See pages 47 - 108 for financial disclosure information.

9:53 am
(p. 249)
PAPER #85

Does Physical Therapy Predict Outcomes after Ankle Fractures and Ankle Fracture-Dislocations?
Chad Ferguson, MD*; Luke Harmer, MD, MPH, FRCSC; Rachel Seymour, PhD; J Kent Ellington, MD; CAPT (ret) Michael Bosse, MD*

9:59 am
(p. 251)
PAPER #86

Peroneal Irritation After Lateral Malleolar Fractures
Paul Tornetta, MD; ***Margaret Cooke, MD****; Clifford Jones, MD, FACS; Janos Ertl, MD; Brian Mullis, MD; Kenneth Egol, MD; Michael Gardner, MD; William Ricci, MD; David Teague, MD; William Ertl, MD; Laura Phieffer, MD; Cory Collinge, MD; Ross Leighton, MD, FRCSC, FACS*

10:05 am
(p. 253)
PAPER #87

Reduction Clamp Force Associated with Syndesmotic Over-Compression: A Pilot Study
Jacob Haynes, MD*; Steven Cherney, MD; Amanda Spraggs-Hughes, MA; Christopher McAndrew, MD; William Ricci, MD; Michael Gardner, MD*

10:11 am Discussion

10:16 am
(p. 255)
PAPER #88

A Clinical Comparison of Treatment of Deltoid Ligament Injuries in Ankle Fracture: Repairing the Deep Deltoid or Superficial or NOT
Xu Sun, MD*; Ting Li, MD; Yuneng Li, MD; Xie-Yuan Jiang, MD; Xinbao Wu, MD; Manyi Wang, MD*

10:22 am
(p. 257)
PAPER #89

The Diagnostic Accuracy of Mortise Radiographs and MRI in Predicting Deltoid Ligament Ruptures in Supination External Rotation Ankle Fractures
Stephen Warner, MD, PhD*; Matthew Garner, MD; Peter Fabricant, MD, MPH; Patrick Schottel, MD; Michael Loftus, MD; Keith Hentel, MD; David Helfet, MD; Dean Lorich, MD*

10:28 am
(p. 259)
PAPER #90

Medial Clamp Tine Positioning Using Intraoperative Fluoroscopy Affects Syndesmosis Malreduction
Christopher Cosgrove, MD*; Sara Putnam, MD; Steven Cherney, MD; William Ricci, MD; Amanda Spraggs-Hughes, MA; Christopher McAndrew, MD; Michael Gardner, MD*

10:34 am Discussion

10:39 am
(p. 261)
PAPER #91

The Failed Pilon: Factors Associated with Delayed Amputation, Arthroplasty, or Arthrodesis after Open Reduction and Internal Fixation
Mara Schenker, MD*; Daniel Patton, MD; Jonathan Kark, MD; David Barei, MD; Daphne Beingessner, MD*

10:45 am
(p. 262)
PAPER #92

Fixation of Tibial Pilon Fractures: Which Side of the Tibia Do I Plate?
Gennadiy Busel, MD*; J Tracy Watson, MD; Heidi Israel, PhD, RN*

SATURDAY, OCTOBER 10, 2015

10:51 am (p. 263) PAPER #93	**Predictors of Amputation in High-Energy Forefoot and Midfoot Injuries** ***Zachary Working, MD***; *Iain Elliott, MD; Lucas Marchand, MD; Lance Jacobson, MD; Angela Presson, PhD; Ami Stuart, PhD; Thomas Higgins, MD; Erik Kubiak, MD; David Rothberg, MD*
10:57 am (p. 265) PAPER #94	**A Randomized, Prospective Comparison of Bioabsorbable and Steel Screw Fixation of Lisfranc Injuries** ***Jamal Ahmad, MD***
11:03 am	Discussion
11:00 am – 12:15 pm	**Concurrent Sessions** ***(General Session and Mini Symposia Breakouts run concurrently.)*** Mini-Symposia Scientific Paper Session 7: Hip Fractures

11:00 am – 12:15 pm

MINI SYMPOSIA

From Good to Great: *(Seaport F – 2nd Flr, Seaport Tower)*
Improving your Treatment of Pelvic Trauma
Moderators: *Jaimo Ahn, MD* and *Derek Donegan, MD*
Faculty: *Andrew R Burgess, MD; David L Helfet, MD; Milton L 'Chip' Routt, MD; H Claude Sagi, MD* and *Adam J Starr, MD*

Disaster Management: Are You Prepared? *(Seaport G – 2nd Flr, Seaport Tower)*
Moderator: *Samir Mehta, MD*
Faculty: *Paul T Appleton, MD; James C Krieg, MD; Christian N Mamczak, DO* and *Saqib Rehman, MD*

The 8 Practices of Highly Successful Surgeons *(Seaport H – 2nd Flr, Seaport Tower)*
Moderator: *Jeffrey M Smith, MD*
Faculty: *Virginia Aherin, CPC; Tambre Leighn, CPC* and *Chris Moody, CPC*

See pages 47 - 108 for financial disclosure information.

(Seaport ABCDE) **11:08 am – 12:22 pm**	**SCIENTIFIC PAPER SESSION 7** **HIP FRACTURES** **Moderators - Michael J Gardner, MD & Dean G Lorich, MD**
11:08 am (p. 267) PAPER #95	**Femoral Neck Shortening Is Associated with Worse Functional Outcome: Analysis of The Prospective Multi-Center Study of Hip Fracture Outcomes in China (SHOC)** ***Gerard Slobogean, MD, MPH, FRCSC***; *David Stockton, MD; Bingfang Zeng, MD; Dong Wang, MD; Andrew Pollak, MD; Baotong Ma, MD*
11:14 am (p. 268) PAPER #96	**A Case-Control Study of Total Hip Arthroplasty after Failed Proximal Femoral Fracture Fixation:** ***David Walmsley, MD***; *Zachary Morison, MSc; Aaron Nauth, MD, FRCSC; Michael McKee, MD; James Waddell, MD, FRCSC; Emil H Schemitsch, MD*
11:20 am	Discussion
11:25 am (p. 270) PAPER #97	**Hip Fracture Treatment at Orthopaedic Teaching Hospitals: Better Care at a Lower Cost** *Sanjit Konda, MD;* ***Arthur Manoli, BS***; *Karan Patel, BS; Kenneth Egol, MD*
11:31 am (p. 271) PAPER #98	**Is it Safe to Operate on Therapeutically Anticoagulated Hip Fractures?** ***David Saper, MD***; *Kyle Lybrand, MD; Kasey Bramlett, PA-C; Michael Kain, MD; Paul Tornetta, MD; Peter Althausen, MD, MBA; Andrew Marcantonio, DO, MBA*
11:37 am (p. 273) PAPER #99	**Short vs Long Cephalomedullary Nails for Fixation of Stable vs. Unstable Intertrochanteric Femur Fracture at a Level I Trauma Center** *Michael Beebe, MD;* ***D Andrew Hulet, BS***; *Casey Whale, BS; Chong Zhang, MS; Jeremy Gililland, MD; David Rothberg, MD; Erik Kubiak, MD*
11:43 am	Discussion
11:48 am (p. 275) PAPER #100	**Myth or Taboo? Use of Long Threaded Screws in Femoral Neck Fractures** ***Kyu Hyun Yang, MD***; *Hyung Keun Song, MD; Jun Young Chung, MD; Dong Hyun Kang, MD; Xuanlin Zheng, MD*
11:54 am (p. 277) PAPER #101	**Percutaneous Cannulated Screw Versus Dynamic Hip Screw Fixation for Intracapsular Femoral Neck Fracture: A Comparative Study** ***Girish Swamy, MRCS***; *Ali Shah, MRCS; Sami Hassan, MRCS; Abdul Aziz, MRCS; Christopher Moran, MD, FRCS; Daren Forward, MD*
12:00 pm	Discussion

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.

12:05 pm (p. 278) PAPER #102
Relationship between the Charlson Comorbidity Index and Cost of Treating Geriatric Hip Fractures: Implications for Bundled Payment
Daniel Johnson, BS; Vasanth Sathiyakumar, BA; Sarah Greenberg, BA; Rachel Thakore, BS; Jesse Ehrenfeld, MD, MPH; Hassan Mir, MD, MBA; Amir Jahangir, MD; William Obremskey, MD, MPH; ***Manish Sethi, MD***

12:11 pm (p. 280) PAPER #103
Missing Data May Invalidate Hip Fracture Database Studies
Bryce A Basques, MD, MHS*; Adam Lukasiewicz, MSc; Andre Samuel, BBA; Matthew Webb, BA; Daniel D Bohl, MD, MPH; Jonathan Grauer, MD*

12:17 pm — Discussion

12:22 - 1:22 pm — **Lunch** and
LAST OPPORTUNITY to Visit Scientific Posters & Technical Exhibits
(All in Grand Hall ABCD – Lobby Level)

12:35 – 1:20 pm GUIDED POSTER TOURS *Tickets Required*

(PT5) **Knee/Tibia** *(Grand Hall ABCD – Lobby Level)*
Guide: *J. Tracy Watson, MD*

(PT6) **Reconstruction/General Interest** *(Grand Hall ABCD – Lobby Level)*
Guide: *Michael J. Gardner, MD*

1:22 pm - 3:00 pm — **Concurrent Sessions**
(General Session and Mini Symposia Breakouts run concurrently.)
Mini-Symposia (1:30 pm - 3:00 pm)
Scientific Paper Session 8: Infection / General Interest II

SCIENTIFIC PAPER SESSION 8
INFECTION & GENERAL INTEREST II

(Seaport ABCDE)
1:22 – 3:00 pm
Moderators - David Sanders, MD & Jason Lowe, MD

1:22 pm (p. 282) PAPER #104
Topical Vancomycin Powder Decreases the Incidence of *Staphylococcus aureus* Infections in Operatively Treated Fractures
Rabah Qadir, MD*; Timothy Costales, BS; Max Coale, BA; Timothy Zerhusen, BS; Manjari Joshi, MD; Robert O'Toole, MD*

1:28 pm (p. 283) PAPER #105
Topical Antibiotics for Infection Prophylaxis in Pelvic and Acetabular Surgery
Matthew Owen, MD*; Jason Lowe, MD; Emily Keener, DO; Zane Hyde, MD; Reaves Crabtree, BS*

See pages 47 - 108 for financial disclosure information.

1:34 pm (p. 284) PAPER #106	**∆ Vancomycin Powder Reduces Infection in an Open Fracture Model** ***David Tennent, MD****; Stefanie Shiels, PhD; Carlos Sanchez, PhD; Daniel Stinner, MD; Joseph Wenke, PhD*
1:40 pm	Discussion
1:45 pm (p. 286) PAPER #107	**Open Ankle Fractures: What Predicts Infection?** *Paul Tornetta, MD;* ***Margaret Cooke, MD****; Douglas Weinberg, MD; Heather Vallier, MD; Reza Firoozabadi, MD; Timothy Alton, MD; Megan Shimota, MD; CAPT (ret) Michael Bosse, MD; Jerald Westberg, BA; Daniel Leas, MD; Michael Archdeacon, MD; Rafael Kakazu, MD; Robert O'Toole, MD; Timothy Costales, BS; Brian Mullis, MD; Kenneth Egol, MD; Stephen Kottmeier, MD; David Sanders, MD; Clifford Jones, MD, FACS; Anna Miller, MD, FACS*
1:51 pm (p. 288) PAPER #108	**Fracture Union Following Infected Hardware Fixation: A Prospective Population Based Cohort Study** ***Daniel Benz, MBBS****; Nick Fountas, MBBS; Reza Rahim, MBBS; Mark Loewenthal, FRACP; Khine Swe, MBBS; David Dewar, FRACS (Ortho)*
1:57 pm (p. 290) PAPER #109	**Correlation between Routine Microbiology Results at Definitive Closure and Wound Infection in Type III Tibia Fractures: Results from a Multi-Center, Prospective Cohort Study** ***CAPT (ret) Michael Bosse, MD****; METRC Bioburden*
2:03 pm	Discussion
2:08 pm (p. 292) PAPER #110	**Culture Negative Infection After Traumatic Injury** ***I Leah Gitajn, MD****; Marilyn Heng, MD; Michael Weaver, MD; Mitchel Harris, MD*
2:14 pm (p. 294) PAPER #111	**Can MRSA Screening Swabs Help Predict Risk of Post-Operative Infection Following Open Fracture Treatment?** ***Cassandra Cardarelli, MD****; Matt Vasquez, MD; Jacob Glaser, MD; Sarah Murthi, MD; Michelle Romero, BS; Kerry Campbell, BS; Michael McCusker, BS; Marcus Sciadini, MD; Robert O'Toole, MD; Manjari Joshi, MD*
2:20 pm (p. 296) PAPER #112	**Vancomycin and Cefepime Antibiotic Prophylaxis for Open Fractures Reduces the Infection Rates in Grade III Open Fractures Compared to Cefazolin and Gentamicin, Avoids Potential Nephrotoxicity, and Does Not Result in Antibiotic Resistance with MRSA** *Benjamin Maxson, DO;* ***Rafael Serrano-Riera, MD****; Mark Bender, DC; H Claude Sagi, MD*
2:26 pm	Discussion
2:31 pm (p. 297) PAPER #113	**A Supply and Demand Analysis of the Orthopaedic Trauma Surgeon Workforce in the United States** ***John Sielatycki, MD****; Hassan Mir, MD, MBA; Jeffrey Sawyer, MD*

∆ OTA Grant

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.

2:37 pm (p. 299) PAPER #114
Effect of a Dedicated Orthopaedic Advanced Practice Provider in a Level I Trauma Center: Analysis of Length of Stay and Cost
Elise Hiza, MD; *Michael Gottschalk, MD; Erica Umpierreze, BA; Patricia Bush, MS; William Reisman, MD*

2:43 pm (p. 301) PAPER #115
Does Nutritional Intervention Improve Nutritional Outcomes in Orthopaedic Trauma Patients: A Randomized Prospective Study
Reza Firoozabadi, MD; *Benjamin Hamilton, BS, MS; Julie Agel, ATC; M Bradford Henley, MD, MBA, FACS*

2:49 pm (p. 303) PAPER #116
Do Patients Know their Post-Operative Plan? A Prospective Cohort Study of Orthopaedic Trauma Patients
Adam Jester, MD; *Christopher Ruland, MS; Ebrahim Paryavi, MD, MPH; Max Coale, BA; Timothy Zerhusen, BS; Robert O'Toole, MD*

2:55 pm Discussion

1:30 pm - 3:00 pm **Concurrent Sessions**
(General Session and Mini Symposia Breakouts run concurrently.)
Mini-Symposia
Scientific Paper Session 8: Infection/Gen. Interest II (1:22 pm - 3:00 pm)

1:30 – 3:00 pm

MINI SYMPOSIA

From the Operating Room to the Boardroom - Applying an MBA to Benefit Orthopaedic Traumatology *(Seaport F – 2nd Flr, Seaport Tower)*
Moderator: *Hassan R Mir, MD, MBA*
Faculty: *Peter L Althausen, MD, MBA; David J Hak, MD, MBA; M Bradford Henley, MD, MBA; Robert A Probe, MD; Craig S Roberts, MD, MBA* and *George V Russell, MD, MBA*

ORIF Versus Acute Arthroplasty for Common Extremity Injuries: What Does Evidence-Based Medicine Tell Us? *(Seaport G – 2nd Flr, Seaport Tower)*
Moderator: *Emil H Schemitsch, MD*
Faculty: *Hans Kreder, MD; Michael McKee, MD; Aaron Nauth, MD* and *Andrew Schmidt, MD*

3:00 - 3:15 pm Refreshment Break *(Seaport Ballroom Foyer)*

See pages 47 - 108 for financial disclosure information.

(Seaport ABCDE) **3:15 – 5:10 pm**	**SCIENTIFIC PAPER SESSION 9 UPPER EXTREMITY AND WRIST** **Moderators - Gerard P Slobogean, MD & Raymond A Pensy, MD**
3:15 pm (p. 305) PAPER #117	**Anterior-Inferior Plating Results in Fewer Secondary Interventions Compared to Superior Plating for Acute Displaced Mid-Shaft Clavicle Fractures** ***Rafael Serrano-Riera, MD***; *H Claude Sagi, MD; Roy Sanders, MD*
3:21 pm (p. 306) PAPER #118	**Introducing the Surgical Therapeutic Index in Trauma Surgery: An Assessment Tool for the Benefits and Risks of Different Operative Fracture Treatment Strategies** ***Olivier Van Der Meijden, MD, PhD***; *Marijn Houwert, MD, PhD; Frans-Jasper Wijdicks, MD, PhD; Marcel Dijkgraaf, PhD; Luke Leenen, Prof. dr.; Michael Verhofstad, MD, PhD; Egbert JMM Verleisdonk, MD, PhD*
3:27 pm (p. 308) PAPER #119	**Effects of Injury and Social Factors on Functional Outcomes After Clavicle Fracture** ***Joshua Napora, MD***; *Dominic Grimberg, BS; Benjamin Childs, BS; Heather Vallier, MD*
3:33 pm	Discussion
3:38 pm (p. 310) PAPER #120	**Results and Outcomes After Midshaft Clavicle Fracture: Matched Pair Analysis of Operative Versus Non-Operative Management** *Joshua Napora, MD;* ***Dominic Grimberg, BS***; *Benjamin Childs, BS; Heather Vallier, MD*
3:44 pm (p. 311) PAPER #121	**Scapular Dyskinesis Following Displaced Fractures of the Middle Clavicle** ***Edward Shields, MD***; *Caleb Behrend, MD; Tanya Beiswenger, DPT; Benjamin Strong, MD; Michael Maloney, MD; Ilya Voloshin, MD*
3:50 pm (p. 312) PAPER #122	**Proximal Humerus Fracture Fixation with Locking Plate: Screws with a Length of 45 mm or Longer Are Related to Increased Risk of Cut-Out** ***Julien Goulet, MD***; *Jérémie Ménard, Ing; Julien Chapleau, MD, MSc; Georges-Yves Laflamme, MD, FRCSC; Dominique Rouleau, MD, MSc, FRCSC*
3:56 pm	Discussion
4:01 pm (p. 313) PAPER #123	**The Impact of Residual Angulation on Patient Reported Functional Outcome Scores after Non-operative Treatment for Humeral Shaft Fractures** ***Edward Shields, MD***; *Leigh Sundem, BS; Sean Childs, BS; Michael Maceroli, MD; Catherine Humphrey, MD; John Ketz, MD; Gillian Soles, MD; John Gorczyca, MD*

SATURDAY, OCTOBER 10, 2015

4:07 pm (p. 316) PAPER #124	**Scoring Cortical Healing of Humeral Shaft Fractures Improves Interobserver Reliability** ***Anthony Christiano, BA****; Abraham Goch, BS; Christopher Burke, MD; Philipp Leucht, MD, PhD; Kenneth Egol, MD; Sanjit Konda, MD*
4:13 pm (p. 317) PAPER #125	**Optional Follow-Up Visits for Common, Low-Risk Arm Fractures** ***Abigail Finger, BA****; Teun Teunis, MD; Michiel Hageman, MD; Emily Thornton, BS; Valentin Neuhaus, MD, PhD; David Ring, MD, PhD*
4:19 pm	Discussion
4:24 pm (p. 318) PAPER #126	**Impact of Olecranon Fracture Malunion: Study on the Importance of PUDA (Proximal Ulna Dorsal Angulation)** ***Julien Chapleau, MD, MSc****; Frédéric Balg, MD, FRCSC; Edward Harvey, MD, MSc, FRCSC; Jérémie Ménard, Ing; Frédéric Vauclair, MD; George Laflamme, MD; Dominique Rouleau, MD, MSc, FRCSC*
4:30 pm (p. 319) PAPER #127	**Surgical Treatment of Chronic Elbow Dislocation Allowing Early Range of Motion: Operative Technique and Early Clinical Results** ***Justin Haller, MD****; Lucas Anderson, MD; Duane Anderson, MD*
4:36 pm (p. 320) PAPER #128	**Posttraumatic Elbow Arthrofibrosis Incidence and Risk Factors: A Retrospective Review** ***Lucas Marchand, MD****; Zachary Working, MD; J Williams, MD; Iain Elliott, MD; Ami Stuart, PhD; David Rothberg, MD; Thomas Higgins, MD; Erik Kubiak, MD*
4:42 pm (p. 322) PAPER #129	**Early Mobilization Versus Plaster Immobilization of Simple Elbow Dislocations: A Cost Analysis of the FuncSiE Multicenter Randomized Clinical Trial** *GIT Iordens, MD; Esther Van Lieshout, PhD, MSc; Suzanne Polinder, PhD; Denise Eygendaal, MD, PhD; Michael Verhofstad, MD, PhD; Niels Schep, MD, MSc, PhD;* ***Dennis Den Hartog, MD, PhD***
4:48 pm	Discussion
4:53 pm (p. 323) PAPER #130	**Dorsal Tangential View: A Useful Tool for Assessment of Dorsal Screw Penetration in Distal Radius Fracture Fixation?** ***Devin Ganesh, MD****; Ben Service, MD; Brian Zirgibel, MD; Kenneth Koval, MD*
4:59 pm (p. 324) PAPER #131	**Timing of Treatment of Open Distal Radial Fractures in Adults** ***Jarid Tareen, MD****; Adam Kaufman, MD; Raymond Pensy, MD; Robert O'Toole, MD; W Andrew Eglseder, MD*
5:05 pm	Discussion
5:10 pm	Closing Remarks and ADJOURN
	See you next year in Washington, DC, October 5 - 8, 2016

See pages 47 - 108 for financial disclosure information.

Aarabi, Bizhan	*(n)*	Paper 61
Abadie, Bryan	*(n)*	Poster 99
Abdelgawad, Amr	*(1,7-Springer; 6-Synthes)*	Poster 119
Abzug, Joshua	*(2-Checkpoint Surgical; 3B-Axogen; 7-Springer)*	Paper 63; Poster 113
Acharya, Mehool	*(n)*	Poster 86
Achor, Timothy	*(3B-Synthes)*	Mini Symposium Faculty; Case Presentation Faculty
Adams, Mark	*(n)*	Poster 80
Achor, Timothy	*(3B-Synthes)*	Skills Lab Faculty; Poster 87
Adams, Mark	*(n)*	Poster 80
Adams, Tracy	*(n)*	Paper 33
Adler, Ronald	*(n)*	Poster 132
Agel, Julie	*(9-American Orthopaedic Society for Sports Medicine; Orthopaedic Trauma Association)*	Paper 69, 81, 115
Ahn, Jaimo	*(3B-Synthes; 3C-Skelegen; 7-Cochrane; 8-Fronteirs in Surgery; Journal of Orthopaedic Trauma; 9-AAOS; American Orthopaedic Association; American Physician Scientists Association; Foundation for Orthopaedic Trauma; NBME; Orthopaedic Research Society; Orthopaedic Trauma Association)*	Mini Symposium Moderator; Mini Symposium Faculty
Aherin, Virginia	*(n)*	Mini Symposium Faculty
Ahmad, Jamal	*(5-Merz Pharmaceuticals; 9-American Academy of Orthopaedic Surgeons, American Orthopedic Foot & Ankle Society*	Paper 94

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Ahn, Jaimo	*(3B-Synthes; 3C-Skelegen; 7-Cochrane; 8-Fronteirs in Surgery; Journal of Orthopaedic Trauma; 9-AAOS; American Orthopaedic Association; American Physician Scientists Association; Foundation for Orthopaedic Trauma; NBME; Orthopaedic Research Society; Orthopaedic Trauma Association)*	Skills Lab Faculty; Mini Symposium Moderator; Mini Symposium Faculty
Ahn, Junyoung	*(n)*	Poster 56
Ajam, Kamal	*(n)*	Mini Symposium Faculty
Al Muderis, Munjed	*(1-Global Orthopaedics; Permedica; 3B-CORIN Australia; Endo-Exo Pty Ltd; Global Orthopaedics; Lima Orthopedics)*	Poster 29
Al-Abbasi, Khaled	*(n)*	Poster 67
Albanese, Matthew	*(n)*	Poster 46
Alhandi, Ali	*(n)*	BSFF Paper 19
Alsberg, Eben	*(n)*	BSFF Paper 9
Althausen, Peter	*(4-The Orthopaedic Implant Company; 8-Editor for Journal of Orthopaedic Trauma; 9-Orthopaedic Trauma Association Fund Development Comm.)*	Mini Symposium Moderator; Mini Symposium Faculty; Paper 98
Alton, Timothy	*(n)*	Paper 107; Poster 81
Alzahrani, Mohammad	*(n)*	BSFF Paper 7
Andersen, COL Romney C	*(9- Peer Reviewed Orthopaedic Research Program; Extremity War Injuries; Orthopaedic Trauma Association)*	METRC
Anderson, Donald	*(4-FxRedux Solutions)*	Paper 48
Anderson, Duane	*(n)*	Paper 127
Anderson, Lucas	*(n)*	Paper 127
Andres, Brendan	*(n)*	Paper 60
Anglen, Jeff	*(3B-DJ Orthopaedics, Eli Lilly)*	FLOW Investigator

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Anraku, Yoshihisa	*(n)*	Paper 37
Apfeld, Jordan	*(n)*	Poster 70
Apivatthakakul, Theerachai	*(n)*	BSFF Papers 22, 23
Appleton, Paul T	*(2-Synthes)*	Mini Symposium Faculty; Poster 44
Archdeacon, Michael	*(1-Stryker; 3B-Stryker; 7-SLACK Incorporated; 8-Journal of the American Academy of Orthopaedic Surgeons; 9-Ohio Orthopaedic Society; Orthopaedic Trauma Association)*	OTA BOD; Case Presentation Faculty; BSFF Symposium Faculty; Paper 65, 107; Poster 88, 111
Archer, Kristin	*(n)*	Symposium Faculty
Asch, Manuel	*(n)*	BSFF Paper 10
Attum, Basam	*(n)*	Symposium Faculty; Poster 5
Au, Brigham	*(n)*	BSFF Paper 17
Augat, Peter	*(6-Apex Biomedical LLC)*	BSFF Paper 10
Aung, Htay	*(n)*	Skills Lab Faculty
Auston, Darryl	*(n)*	Poster 46
Avery, Matthew	*(n)*	Poster 99
Avilucea, Frank	*(n)*	Paper 38, 70; Poster 5, 53, 59, 69
Azer, Emil	*(n)*	Poster 46
Aziz, Abdul	*(n)*	Paper 101
Backstein, David	*(1-Microport Orthopaedics; 3-Zimmer Orthopaedics; 4-Intellijoint Orthopaedics; 8-Journal of Arthroplasty. Clinical Orthopaedics and Related Research)*	BSFF Paper 18
Bae, Donald S	*(n)*	Paper 53
Bailey, Christopher	*(n)*	Paper 33
Baixauli Garcia, Francisco	*(n)*	Paper 43
Baker, Ronald	*(4-Zimmer)*	Poster 6

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Bakhsh, Wajeeh	*(3A-Norvartis)*	Poster 103
Balg, Frédéric	*(2-Smith & Nephew; 5-DepuySynthes, Tornier)*	Paper 126
Bannister, Evan	*(n)*	Poster 73
Barcak, Eric	*(n)*	Poster 108
Barclay, Jonathan	*(n)*	Paper 58
Barei, David	*(2,3B,5-Synthes; 5-Zimmer; 9-AO/ASIF)*	Paper 91
Beaty, James	*(7-Saunders/Mosby-Elsevier; 8-Journal of Bone and Joint Surgery; 9-Orthopaedic Research and Education Foundation)*	Poster 76
Barla, Jorge	*(n)*	BSFF Paper 3
Barralet, Jake	*(J Biomed Mater Res (A & B), Acta Biomaterialia, J Biomter Applicns, Regenerative Engineering and Translational Medicine, Biomaterials Research; 9-Controlled Release Society)*	BSFF Paper 29
Bartley, Debra	*(n)*	Paper 33
Basmajian, Hrayr	*(n)*	Paper 77
Basques, Bryce	*(n)*	Paper 78, 103; Poster 56, 66, 98
Bastrom, Tracey	*(n)*	Paper 50; Poster 74, 75
Baxter, Josh	*(n)*	BSFF Paper 15
Beaty, James	*(7-Saunders/Mosby-Elsevier; 8-Journal of Bone and Joint Surgery; 9-Orthopaedic Research and Education Foundation)*	Poster 76
Beaupre, Lauren	*(n)*	Paper 54; Poster 67
Beebe, Michael	*(n)*	BSFF Paper 16; Paper 99; Poster 18
Behrend, Caleb	*(n)*	Paper 121
Beingessner, Daphne	*(2-AO North America; 3B,5-Synthes)*	Paper 91

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Beiswenger, Tanya	*(n)*	Paper 121
Belinga, Patrick	*(n)*	Poster 43
Bell, Anthony	*(n)*	Poster 78
Bender, Mark	*(n)*	Paper 112
Benirschke, Stephen	*(n)*	Poster 9
Benz, Daniel	*(n)*	Paper 108
Bergman, Joseph	*(n)*	Paper 54; Poster 67
Berkes, Marschall	*(n)*	Poster 41
Bernard, Johnathan	*(n)*	Poster 57
Bernstein, Mitchell	*(n)*	BSFF Symposium Faculty; Skills Lab Faculty; Paper 56, 58; Poster 19
Besh, Basil R	*(9-AAOS)*	Mini Symposium Faculty
Bhandari, Mohit	*(3B-Amgen Co; Eli Lilly; Stryker; Smith & Nephew; Zimmer; Stryker; Moximed; Bioventus; 5-Smith & Nephew; DePuy, A Johnson & Johnson Company; Eli Lily; Bioventus)*	Basic Science Committee; BSFF Symposium Moderator; Symposium Moderator; Paper 35; FLOW Investigator
Bharmal, Husain	*(n)*	BSFF Paper 26; Poster 130
Bihari, Aurelia	*(n)*	BSFF Paper 28
Billiar, Timothy	*(n)*	BSFF Symposium Moderator; BSFF Moderator
Bishop, Danett	*(n)*	BSFF Paper 25
Bishop, Julius	*(1-Innomed; 2-Synthes; 5-Covidien)*	Poster 24, 83
Bledsoe, Gary	*(n)*	BSFF Paper 11
Bodrogi, Andrew	*(n)*	BSFF Paper 14
Bogdan, Yelena	*(9-AAOS)*	Poster 15
Bohatyrewciz, Andrzej	*(n)*	Paper 43
Bohl, Daniel	*(n)*	Paper 78, 103; Poster 56, 66, 98
Bohm, Kyle	*(n)*	Poster 114

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Boileau, Pascal	*(1-Tornier; 3C-Smith & Nephew; 6-Imascap)*	Poster 116
Born, Christopher	*(3B-Illuminoss; Stryker; 3C-Biointraface; 4-Biointraface; Illuminoss; 5-Stryker; 9-American College of Surgeons; Orthopaedic Trauma Association; AAOS; Foundation for Orthopaedic Trauma)*	Paper 73; Poster 50
Borrelli, Joseph Jr	*(2; 3B-Eli Lilly; 7-Springer)*	Basic Science Committee; BSFF Symposium Moderator
Bosse, Michael	*(4-Orthopaedic Implant Company)*	Paper 85, 107, 109; Poster 58, 107; METRC
Bottlang, Michael	*(1-Synthes; Zimmer; 2-Synthes; Zimmer; 3A-APEX Biomedical; 3B-Synthes; Zimmer; 5-Zimmer)*	BSFF Symposium Moderator; BSFF Paper 10
Boulton, Christina	*(n)*	Paper 71
Bowen, Stephen	*(n)*	Paper 39
Boyce, Robert	*(n)*	Poster 17
Bramlett, Kasey	*(n)*	Paper 98
Bray, Timothy	*(2-Kaiser Permenente honorarium for annual trauma update; 3C-Anthem Orthopaedics, FlexFix, Orthopaedic Implant Company; 4-Anthem Orthopaedics, Orthopaedic Implant Company, FlexFix; 6-Renown Regional Medical Center-Fellowship Funding, COTA/OTA -Fellowship Funding; 8-Orthopaedic Trauma Association, President 2010-2011)*	Mini Symposium Faculty
Brealey, Stephen	*(n)*	Paper 32
Breslin, Mary	*(n)*	Mini Symposium Faculty
Briggs, Andrew	*(n)*	Paper 31

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Brock, Kenneth	*(n)*	Poster 132
Broder, Kari	*(n)*	Poster 14, 112, 120
Broekhuyse, Henry	*(2,5-Synthes; 8-Journal of Orthopaedic Trauma; 9-AAOS; American Orthopaedic Association; AOA - CORD governing council; Canadian Orthopaedic Association)*	Paper 42
Brown, Anthony	*(4-Orthopaedic Implant Company)*	Skills Lab Faculty
Bryant, Dianne	*(n)*	Paper 33
Buckley, Richard	*(n)*	Paper 54; Poster 52
Budsberg, Steven	*(2-Merial and Zoetis Pharmaceuticals; 5-Piedmont Pharmaceutical and Morris Foundation)*	Poster 68
Buford, William	*(n)*	BSFF Paper 4
Bugler, Kate	*(n)*	Paper 30
Bulka, Catherine	*(n)*	Poster 6, 69
Bundkirchen, Katrin	*(n)*	BSFF Paper 2, 27
Burgess, Andrew R	*(1-Stryker; 3B-Cardinal Health; Stryker)*	Mini Symposium Faculty; METRC
Burgos, Eduardo	*(n)*	Poster 6
Burke, Christopher	*(n)*	Paper 124
Busel, Gennadiy	*(n)*	Paper 92
Bush, Patricia	*(n)*	Paper 114
Busse, Jason	*(5-Smith & Nephew co-funded the TRUST trial)*	Paper 35
Caba, Pedro	*(2; 3B; 5-Smith & Nephew; 8-Revista Esnola de Corugia Ortoedica y Traumatologia; 9-AO Trauma Spain, Board of Education)*	Paper 34
Caban-Martinez, Alberto	*(n)*	Poster 12
Caffes, Nicholas	*(n)*	Paper 61

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Campbell, Kerry	*(n)*	Paper 111
Canetti, Lissette Salgueiro	*(n)*	Poster 74, 75
Cannada, Lisa K	*(2-Smith & Nephew; 3B-Zimmer)*	Case Presentation Moderator; Mini Symposium Moderator; BSFF Paper 11; Poster 42, 99; METRC
Capo, John	*(1-Wright Medical Technology, Inc.; 2-Integra Life Sciences; 3B-Wright Medical Technology, Inc.; 7-Informa Healthcare; 8-Journal of Bone and Joint Surgery - American; Journal of Hand Surgery - American; Journal of Orthopaedics and Traumatology)*	Poster 132
Cardarelli, Cassandra	*(n)*	Paper 111
Carey, Tim	*(n)*	Paper 33
Caroom, Cyrus	*(n)*	Poster 31
Carroll, Eben A	*(2-Smith & Nephew; Synthes; Zimmer; 3B-Smith & Nephew; Synthes; 5-Smith & Nephew; Synthes; 6-Smith & Nephew; Synthes; Zimmer 8-Journal of the American Academy of Orthopaedic Surgeons)*	METRC
Castillo, Renan	*(n)*	Symposium Faculty; Paper 55; Poster 71
Castillo, Tiffany	*(n)*	Poster 83
Caswell, Kathleen A	*(n)*	OTA Executive Director
Cepinskas, Gediminas	*(n)*	BSFF Paper 28
Chafey, David H III	*(n)*	Moderator
Chakraborty, Nabarun	*(n)*	BSFF Paper 8
Chapleau, Julien	*(n)*	Paper 122, 126
Chen, Lina	*(n)*	Paper 71

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Cherney, Steven	*(n)*	Paper 84, 87, 90; Poster 13, 103
Chesser, Tim	*(3B-Acumed, LLC; Stryker; 5-Stryker; 9-British Orthopaedic Association; Falls and Fragility Fracture Audit Program (UK)*	Paper 31; Poster 86
Chi, Benjamin	*(n)*	Poster 129
Chien, Bonnie	*(n)*	Poster 24
Childress, Paul	*(n)*	BSFF Paper 8
Childs, Benjamin	*(4-Edwards Life Sciences)*	Paper 60, 119, 120; Poster 95
Childs, Sean	*(n)*	Paper 123
Chiu, Michael	*(n)*	Poster 7
Cho, Hyun Joong	*(n)*	Poster 49
Christian, Matthew	*(n)*	Poster 92
Christiano, Anthony	*(n)*	Paper 41, 44, 124; Poster 61, 100, 101, 115, 120
Chu, Tien-Min	*(n)*	BSFF Paper 8
Chuang, Ling-Hsiang	*(n)*	Paper 32
Chung, Jun Young	*(n)*	Paper 100
Clarke-Jenssen, John	*(n)*	Paper 68
Clavert, Philippe	*(3B-Tornier, SA)*	Poster 116
Coale, Max	*(n)*	Paper 55, 104, 116; Poster 92
Cochran, Grant	*(n)*	Poster 25
Coles, Chad	*(2-Medtronic; 2,3,5-Smith & Nephew; 5-Synthes; Zimmer; 8-Canadian Journal of Surgery; Injury; Journal of Orthopedic Trauma; 9-Canadian Orthopaedic Association; Canadian Orthopaedic Foundation; Orthopaedic Trauma Association)*	Paper 33

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Collinge, Cory	*(1-Biomet; Smith & Nephew; Advanced Orthopedic Solutions, Synthes; 3B-Biomet, Stryker, and Smith & Nephew; 8-Journal of Orthopaedic Trauma; 9-Foundation for Orthopedic Trauma)*	Skills Lab Faculty; Mini Symposium Faculty; Paper 73, 86, 88; Poster 108
Como, John	*(n)*	Poster 95
Cooke, Margaret	*(n)*	Paper 73, 86, 107
Corbacho-Martin, Belen	*(n)*	Paper 32
Corcoran-Schwartz, Ian	*(n)*	Poster 83
Corona, Benjamin	*(n)*	BSFF Symposium Faculty; BSFF Paper 8, 20
Cosgrove, Christopher	*(n)*	Paper 90; Poster 13
Costa, Matthew	*(n)*	Paper 72
Costales, Timothy	*(n)*	Paper 55, 61, 104, 107; Poster 92
Court-Brown, Charles	*(7-Lippincott)*	Paper 30
Crabtree, Reaves	*(n)*	Paper 105
Crawford, Brooke	*(n)*	Poster 42
Crespo, Alexander	*(n)*	Paper 64
Crichlow, Renn	*(2-Stryker; Synthes; 8-Journal of Orthopaedics and Traumatology; Journal of Trauma; Orthopedics)*	Poster 10
Criner, Katharine	*(n)*	Poster 132

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Crist, Brett D	*(3B-DePuy, A Johnson & Johnson Company; KCI; Microport; 4-Amedica Corporation; Orthopaedic Implant Company; 5-Synthes; 6-Wright Medical Technology, Inc.; 8-Journal of Orthopaedic Trauma; Journal of the American Academy of Orthopaedic Surgeons; Orthoinfo.org; 9-International Geriatric Fracture Society; Mid-Central States Orthopaedic Society; Orthopaedic Trauma Association)*	Basic Science Committee; BSFF Symposium Moderator; Case Presentation Moderator
Cuellar, Derly	*(n)*	Poster 134
Cunningham, Brian	*(n)*	Paper 77
Cunningham, Gregory	*(n)*	Poster 43
D'Ollonne, Thomas	*(n)*	Poster 116
Dailey, Steven	*(n)*	Paper 65; Poster 111
Dangelmajer, Sean	*(n)*	Poster 83
Dattilo, Jonathan	*(n)*	Poster 57
Davidovitch, Roy	*(3B-Pacira; Stryker)*	Paper 44, 47, 72
Davis, Derik	*(n)*	Paper 71
Davis, Thomas	*(n)*	BSFF Paper 25
de Muinck Keizer, Robert-Jan	*(n)*	Poster 131
de Pantoja, Vicente Casa	*(n)*	Paper 43
Dehghan, Niloofar	*(n)*	Symposium Faculty; Skills Lab Faculty; Mini Symposium Faculty

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DISCLOSURE LISTING – ALPHABETICAL

Della Rocca, Gregory	*(2-Synthes; 3B-Bioventus; LifeNet; Pacira; Synthes; 4-Amedica; MergeNet; The Orthopaedic Implant Company; 5-Synthes; 8-Geriatric Orthopaedic Surgery and Rehabilitation; 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)*	FLOW Investigator
Delsole, Edward	*(n)*	Poster 109
Den Hartog, Dennis	*(n)*	Paper 129
Detre, Zoltan	*(n)*	Paper 43
Dewar, David	*(n)*	Paper 108
Dhotar, Herman	*(n)*	BSFF Paper 18
Dibbern, Kevin	*(n)*	Paper 48
Dielwart, Cassandra	*(n)*	Poster 91
DiFazio, Rachel L	*(n)*	Paper 53
Dijkgraaf, Marcel	*(n)*	Paper 118
Ding, David	*(n)*	Poster 4
DiSilvio, Frank	*(n)*	Paper 56
Doan, Joshua	*(n)*	BSFF Paper 24
Dobberstein, Diane Vetrovec	*(n)*	OTA Staff
Doi, Takeshi	*(n)*	Paper 37
Donegan, Derek	*(3B-Synthes)*	Case Presentation Faculty; Mini Symposium Moderator; Paper 75; Poster 34
Donohoe, Erin	*(n)*	Poster 51
Donohue, David	*(n)*	Paper 57
Donohue, Duncan	*(n)*	BSFF Paper 8

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Drager, Justin	*(n)*	BSFF Paper 29
Drechsler, Anika	*(n)*	BSFF Paper 10
Dresing, Klaus	*(n)*	Paper 43
Dubina, Andrew	*(n)*	Poster 104
Dubose, Candice	*(n)*	Poster 82
Dubrana, Frederic	*(n)*	Paper 43
Duffy, Paul	*(n)*	Poster 52
Dulai, Sukhdeep	*(5-RGR Pharma; 6-Smith & Nephew; 9-POSNA Comm Member; COA Basic Science Course Board Member; Canadian Paediatric Orthopaedic Group Board Member)*	Paper 54; Poster 67
Dunbar, Robert	*(6-Innovision Corp.; 8-Journal of Orthopaedics and Traumatology; OrthoInfo; 9-AAOS)*	Paper 73
Durbin-Johnson, Blythe	*(n)*	Poster 28
Eastman, Jonathan	*(n)*	Poster 28
Edmonds, Eric	*(2-Arthrex; Orthopediatrics; 5-Inion; 9-AAOS; American Orthopaedic Society for Sports Medicine; Pediatric Orthopaedic Society of North America)*	BSFF Paper 24; Poster 74
Eglseder, W Andrew	*(n)*	Paper 131; Poster 60, 118
Egol, Kenneth A	*(1,3B-Exactech, Inc; 5-OMEGA; OREF; Synthes; 7-SLACK Incorporated; Wolters Kluwer Health - Lippincott Williams & Wilkins)*	OTA BOD; Symposium Faculty; Skills Lab Faculty; Paper 41, 44, 47, 64, 73, 82, 86, 97, 107, 124; Poster 4, 14, 32, 61, 62, 94, 100, 101, 109, 110, 112, 115, 120
Ehrenfeld, Jesse	*(n)*	Paper 102

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DISCLOSURE LISTING – ALPHABETICAL

Einhorn, Thomas	*(2-Bioventus; Harvest; Medtronic; Pfizer; 3B-Anika; BiologicsMD; Bioventus; Harvest; Medtronic; 4-Healthpoint Capital; NeoStem; PolyPid; 7-Journal of Bone and Joint Surgery - American; Lippincott Williams and Wilkins; 8-Journal of Bone and Joint Surgery - American)*	Paper 35
Eitzen, Ingrid	*(n)*	Paper 68
Elfar, John	*(n)*	Poster 16
Elias, John	*(6-Supplies for study provided by Synthes)*	BSFF Paper 13
Ellington, J Kent	*(1-BME; 2-Arthrex; BME; 3B-Amniox, Arthrex;BME; Zimmer; Conventusortho; 4-Medshape; 5-Amniox)*	Paper 85
Elliott, Iain	*(n)*	Paper 93, 128; Poster 133
Entezari, Vahid	*(n)*	Poster 121, 124
Ernat, Justin	*(n)*	Paper 51
Ertl, Janos	*(n)*	Paper 73, 86
Ertl, William	*(2-KCI)*	Paper 73, 86; METRC
Escriba, Ismael	*(n)*	Paper 34
Etier, Brian	*(n)*	Poster 47
Evans, Korboi	*(n)*	Poster 130
Eygendaal, Denise	*(2-Zimmer; 3B-DePuy)*	Paper 129
Faber, Henry	*(n)*	BSFF Paper 12
Fabricant, Peter	*(n)*	Paper 49, 89
Fagg, James	*(n)*	Poster 86
Farnsworth, Christine	*(n)*	BSFF Paper 24
Farrell, Dana	*(n)*	Poster 102
Ferguson, Chad	*(n)*	Paper 85
Ferguson, Stephen	*(5-Project funding by Kuros AG)*	BSFF Paper 6

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Ferguson, Tania	*(2-DePuy; Synthes)*	Case Presentation Faculty
Fichman, Simcha Gil	*(n)*	BSFF Paper 18
Filipkowski, Danielle	*(n)*	BSFF Paper 13
Fine, Landon	*(n)*	Poster 2
Finger, Abigail	*(n)*	Paper 83, 125
Finkemeier, Christopher	*(3B-DePuy, A Johnson & Johnson Company; 3C-Acumed, LLC)*	Case Presentation Faculty
Firoozabadi, Reza	*(n)*	Skills Lab Faculty; Paper 107, 115; Poster 63, 81, 84; METRC
Fitzpatrick, Daniel	*(1-Synthes CMF; 1,2,3B-Zimmer)*	BSFF Paper 10
Fleming, Mark	*(8-Military Medicine; 9-Orthopaedic Trauma Association)*	Poster 130
Flint, Kathy	*(n)*	Poster 10
Flores, Stephen	*(n)*	Poster 31
Fogel, Harold	*(n)*	Poster 19
Fokin, Alex Jr	*(n)*	Poster 12
Formby, Peter	*(n)*	Poster 126
Forsberg, Jonathan	*(3B-Clementia Pharmaceuticals)*	BSFF Paper 25
Forward, Daren	*(n)*	Paper 34, 101; Poster 27
Fountas, Nick	*(n)*	Paper 108
Foxall, Julia	*(n)*	Paper 33
Foyil, Sarah	*(n)*	Paper 56
Fragomen, Austin	*(2-Smith & Nephew; 3B-Smith & Nephew; Synthes)*	Paper 58
Frantz, Travis	*(n)*	Paper 79; Poster 90
Fras, Andrew R	*(3B-Zimmer Biomet)*	Skills Lab Leader
Freedman, Brett	*(6-Medtronic)*	Poster 125
French, Robert	*(n)*	Poster 106
Friess, Darin	*(3B-Acumed, LLC)*	Paper 73

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DISCLOSURE LISTING – ALPHABETICAL

Frisch, H Michael	*(n)*	Mini Symposium Faculty
Frolke, Jan Paul	*(n)*	Poster 29
Fulkerson, Eric W	*(4-Connexions; Flo Pharma)*	Skills Lab Faculty
Gage, Mark	*(n)*	Paper 75; Poster 34
Galos, David	*(n)*	Paper 75; Poster 32
Galpin, Matthew	*(n)*	Poster 87
Gamulin, Axel	*(n)*	Poster 43
Ganesh, Devin	*(n)*	Paper 130
Gannon, Edwin	*(n)*	Paper 52
Gardner, Michael J	*(3B-BoneSupport AB; Pacira Pharmaceuticals; Stryker; Synthes; 5-Synthes; 7-Wolters Kluwer Health - Lippincott Williams & Wilkins; 9-Orthopaedic Trauma Association)*	Program Committee; Moderator; BSFF Symposium Faculty; Poster Tour Guide; Paper 73, 84, 86, 87, 90; Poster 13, 103
Garner, Matthew	*(n)*	BSFF Paper 15; Paper 40, 46, 49, 89; Poster 41
Gary, Joshua L	*(2-Smith & Nephew; 4-Summitt Medventures; 8-Journal of Bone and Joint Surgery - American; Wolters Kluwer Health - Lippincott Williams & Wilkins; 9-Orthopaedic Trauma Association)*	Mini Symposium Faculty; Paper 62, 71; Poster 87; METRC
Gaski, Greg E	*(n)*	BSFF Symposium Faculty; Paper 79; Poster 90
Gausden, Elizabeth	*(n)*	Paper 46; Poster 41
Gelb, Daniel	*(1-Globus Medical; 1,2-Depuy-Synthes Spine; 4-Advanced Spinal Intellectual Property)*	Paper 61
Gellman, Richard Evan	*(n)*	Skills Lab Faculty
Gengler, Seth	*(n)*	Poster 2

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Giannoudis, Peter V	*(1-Biomet; 2-DePuy, A Johnson & Johnson Company; Medtronic; 3B-Stryker; 5-Biomet; DePuy, A Johnson & Johnson Company; Stryker; 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 Moderator; BSFF Symposium Faculty; Poster Tour Guide; Papers 43, 72
Gibson, Mary	*(n)*	Poster 87
Gibson, Peter	*(n)*	Poster 80
Gilbert, Susannah	*(n)*	BSFF Paper 15, 16; Paper 99; Poster 18, 33
Gililand, Jeremy	*(n)*	Paper 16, 99
Gitajn, I Leah	*(n)*	Paper 110; Poster 1
Glaser, Jacob	*(n)*	Paper 111
Glide, Alex	*(n)*	Poster 55
Goch, Abraham	*(n)*	Paper 64, 82, 124; Poster 14, 61, 62, 100, 112
Godinsky, Ryan	*(n)*	BSFF Paper 13
Goel, Alex	*(n)*	Poster 38
Goesling, Thomas	*(n)*	BSFF Paper 27
Gofton, Wade	*(2-Bayer - Xaralto talk; Zimmer; 3B-Microport; Zimmer; 6-Synthes - institutional research support)*	BSFF Paper 14; Paper 33
Golinvaux, Nicholas	*(n)*	Poster 56
Gonzalez, Tyler	*(n)*	Poster 1
Goodchild, Lorna	*(n)*	Paper 32

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Goodell, Parker	*(n)*	Poster 64
Goodlett, Ronald	*(n)*	BSFF Paper 26
Gorczyca, John	*(8-The Journal of Orthopaedic Trauma)*	Paper 123; Poster 20
Gordon, Lt Col Wade	*(2-Orthofix, LTD; 9-AAOS Trauma Program Comm; OTA Military Comm)*	Poster 127, 128, 129; METRC
Gorecki, Andrzej	*(n)*	Paper 43
Goslings, J.C.	*(n)*	Poster 131
Gottschalk, Michael	*(n)*	Paper 114
Goulet, James A	*(1-Zimmer; 9-Michigan Orthopaedic Society Board Members, AOA "Own the Bone" Steering Committee)*	Mini Symposium Moderator; Paper 69, 76; Poster 36
Goulet, Julien	*(n)*	Paper 122
Graf, Markus	*(n)*	Paper 34
Graham, Dionne	*(n)*	Paper 53
Grauer, Jonathan	*(3B-Bioventus; ISTO Technologies; Medtronic; Stryker; Vertex; 8-American Journal of Orthopedics; Contemporary Spine Surgery; The Spine Journal; 9-AAOS; Cervical Spine Research Society)*	Paper 78, 103; Poster 56, 66, 98
Graves, Matthew L	*(2-Synthes; 3B-Synthes; 5-Synthes; Stryker; 8-Journal of Orthopaedic Trauma)*	Mini Symposium Faculty
Greenberg, Sarah	*(n)*	Paper 102; Poster 5, 6, 17, 53, 54, 59, 69, 70
Greenwell, Patrick	*(n)*	Paper 67

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Grice, Elizabeth	*(2-Johnson & Johnson; L'Oreal; Amyway; 3-GOJO Industries, Inc; Physical Optics Corp; Health Advances, LLC; Steifel; 5-Janssen Research and Development, LLC; 9-Wound Healing Society Program Committee)*	Poster 73
Griffin, Daniel	*(n)*	BSFF Paper 26
Griffis, Clare	*(n)*	Poster 30
Grijalva, Steven	*(n)*	Poster 127, 128
Grimberg, Dominic	*(n)*	Paper 119, 120
Groundland, John	*(n)*	BSFF Paper 17
Gudger, Garland	*(n)*	Poster 105
Gunther, Tibor	*(n)*	Paper 43
Gunton, Matthew	*(n)*	BSFF Paper 18
Gurr, Kevin	*(n)*	Paper 33
Guseila, Loredana	*(n)*	BSFF Paper 13
Guthrie, Stuart	*(9-Michigan Orthopaedic Society)*	Poster 7
Guy, Pierre	*(2,3B,5-Stryker; 4-Traumis Surgical Systems Inc.; 5-Synthes; DePuy, A Johnson & Johnson Company; 9-Canadian Orthopedic Foundation; Orthopaedic Trauma Association; Orthopaedic Trauma Association; West Coast Hip Fracture Society)*	BSFF Symposium Faculty; Mini Symposium Faculty; Case Presentation Faculty; Paper 42; Poster 40
Guyatt, Gordon	*(n)*	Paper 35; FLOW Investigator
Gyftopoulos, Soterios	*(n)*	Poster 61, 62
Haac, Bryce	*(n)*	Poster 92
Haas, Philipp	*(n)*	BSFF Paper 27
Hageman, Michiel	*(n)*	Paper 83, 125
Haider, Adil	*(4-Co-founder & equity shareholder of www.doctella.com)*	Poster 21

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DISCLOSURE LISTING – ALPHABETICAL

Haidukewych, George	*(1,3B-DePuy, A Johnson & Johnson Company; Biomet); 3B,6-Synthes; 4-Orthopediatrics, Institute for Better Bone Health; 8-Journal of Orthopedic Trauma; 9-AAOS)*	Mini Symposium Faculty; Poster 122
Hak, David J	*(2-DePuy, A Johnson & Johnson Company; 3B-Invibio; Kuros Biosurgery; Merck; 7-SLACK Incorporated; 8-Orthopedics;Journal of Orthopaedic Trauma; European Journal of Orthopaedic Surgery; 9-AAOS; International Society for Fracture Repair; Orthopaedic Trauma Association)*	Program Committee; Moderator; Mini Symposium Faculty; METRC
Hale, Mark	*(n)*	Skills Lab Faculty
Haleem, Ambar	*(n)*	Poster 39
Hall, Amber	*(n)*	Poster 44
Haller, Justin	*(n)*	Paper 127; Poster 33
Halvorson, Jason	*(n)*	Poster 48
Hambright, Dustin	*(n)*	Poster 44
Hamdy, Reggie	*(n)*	BSFF Paper 7
Hamershock, Rose	*(n)*	Paper 53
Hamilton, Benjamin	*(n)*	Paper 115; Poster 84
Hammamieh, Rasha	*(n)*	BSFF Paper 8
Hancy, Geoffrey	*(n)*	Poster 122
Handley, Robert	*(9-Pres. Orthopaedic Trauma Society; Chair of NICE)*	Paper 31
Handoll, Helen	*(n)*	Paper 32
Hanley, Matthew	*(n)*	Poster 129
Hanna, Evan	*(n)*	BSFF Paper 5
Hannigan, Geoffrey	*(6-University of Pennsylvania)*	Poster 73
Harmer, Luke	*(n)*	Paper 85; Poster 91
Harries, William	*(n)*	Paper 43

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Harris, Marie	*(n)*	Paper 53
Harris, Mitchel	*(9-North American Spine Society-BOD)*	Paper 110; Poster 21
Hartline, Braden	*(n)*	Poster 87
Harvey, Edward J	*(1,4-Greybox Healthcare; 4-NxtSens; 5-Synthes; 7-Canadian Journal of Surgery; 8-Canadian Journal of Surgery, Journal of Orthopaedic Trauma; Journal of Bone and Joint Surgery - American; 9-Canadian Orthopaedic Association; Orthopaedic Trauma Association)*	Program Committee; BSFF Chair; Basic Science Committee; BSFF Symposium Moderator; BSFF Paper 29; Paper 126
Harvin, William	*(n)*	BSFF Symposium Faculty
Hassan, Sami	*(n)*	Paper 101
Hatzidakis, Armodios	*(1,2,3B,4,5-Tornier)*	Poster 116
Hawkes, Tara	*(n)*	Poster 116
Haws, Brittany	*(n)*	Poster 77
Hax, Peter-Michael	*(n)*	Paper 43
Hayda, Roman	*(2-AONA; Synthes; 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 50
Haynes, Jacob	*(n)*	Paper 87
Hayon, Solomon	*(n)*	Poster 104
Healy, Kaitlin	*(n)*	Poster 99
Hebert-Davies, Jonah	*(n)*	Poster 3
Hecht, Garin	*(n)*	Poster 28
Heckman, James	*(8-The Journal of Bone and Joint Surgery; 9-Orthopaedic Research and Education Foundation)*	Paper 35

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Hedges, Brian	*(n)*	Poster 97
Heels-Ansdell, Diane	*(6-Smith and Nephew)*	Paper 35; FLOW Investigator
Helfet, David L	*(3C-OHK, Healthpoint Capital, TriMedics; 4-OHK Medical Devices; FxDevices)*	Symposium Faculty; Mini Symposium Faculty; Paper 40, 49, 89; Poster 48
Helou, Christine	*(n)*	Paper 63; Poster 113
Heng, Marilyn	*(n)*	Paper 110; Poster 21
Henley, M Bradford	*(1-Renovis; Zimmer; 2-Stryker / Howmedica; Zimmer; 3B-Gerson Lehrman Group; Guidepoint Global; Health Services Asset Management LLC; Milliman Care Guidelines; Premera Blue Cross; Zimmer; 3C-Karen Zupko and Assts; Synergey Surgical (Renovis); 4-Renovis (formerly Synergy Surgical Technologies); 7-Wolters Kluwer Health - Lippincott Williams & Wilkins; 9-AAOS; American Medical Association; Washington State Orthopaedic Society)*	Mini Symposium Faculty; Paper 115
Henrikson, Karl	*(n)*	Poster 102
Henry, Patrick David George	*(n)*	Skills Lab Faculty
Hentel, Keith	*(n)*	Paper 89
Herman, Amir	*(n)*	Poster 82
Hermelin, Michael	*(n)*	Poster 11
Hesketh, Patrick	*(n)*	Poster 73
Hewitt, Catherine	*(n)*	Paper 32
Heydemann, John	*(4-Merck)*	Poster 87

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Higgins, Thomas F	*(3B-DePuy Synthes; 4-Orthogrid; Summit Medical Ventures; 9-Orthopaedic Trauma Association)*	Program Committee; Moderator; BSFF Symposium Faculty; Skills Lab Faculty; Poster Tour Guide; Paper 48, 59, 93, 128; Poster 133
Hill, Austin	*(n)*	Mini Symposium Faculty
Hill, Brian	*(n)*	Poster 114
Hiller, Paul	*(n)*	OTA Staff
Hinds, Richard	*(n)*	Poster 132
Hiza, Elise	*(n)*	Paper 114
Hlavacek, Jimmy	*(n)*	Poster 47
Ho, Christine A	*(7-Wolters Kluwer Health - Lippincott Williams & Wilkins; 9-Pediatric Orthopaedic Society of North America)*	Case Presentation Faculty; Paper 51
Ho, Steve	*(n)*	BSFF Paper 9
Hoffmann, Martin	*(n)*	Poster 26, 55
Hoffmeyer, Pierre	*(2-Bayer; 5-DePuy, A Johnson & Johnson Company; Zimmer; Synthes; Medacta; Abbott; 8-EFORT Open Reviews; Journal of Bone and Joint Surgery - British; 9-AO Foundation, European Federation of National Societies of Orthopaedics and Traumatology, Foundation for Osteo-Articular Research)*	Poster 43
Holt, Daniel	*(n)*	Poster 19
Homen, Dylan	*(n)*	Poster 31
Hopkins, Christopher	*(n)*	Paper 52
Horan, Annamarie	*(1-MSK/Dx, LLC)*	Poster 73
Horne, Brandon	*(n)*	Poster 10
Horwinski, Joseph	*(n)*	Poster 73

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DISCLOSURE LISTING – ALPHABETICAL

Horwitz, Daniel S	*(9-AAOS Foundation for Orthopaedic Trauma; 7-Biomet; 3B-Biomet; Cardinal Health; 5-Synthes; 8-Wolters Kluwer Health)*	Skills Lab Faculty
Houdek, Matthew	*(n)*	Poster 45
Houwert, Marijn	*(n)*	Paper 118
Howard, James	*(2,3B,5,6-DePuy, A Johnson & Johnson Company; 2,3B-Stryker; 6-Microport; Smith & Nephew; Stryker; Zimmer)*	Poster 51
Howes, Cameron	*(n)*	Poster 99
Hsu, Joseph	*(2-Smith & Nephew; 9-Limb Lengthening Research Society)*	Mini Symposium Faculty; Poster 8
Hulet, David	*(n)*	BSFF Paper 16, 99; Poster 18
Humphrey, Catherine	*(n)*	Paper 73, 123; Poster 20
Huntley, Samuel	*(n)*	Poster 12
Hwang, John S	*(n)*	Poster 80
Hyde, Zane	*(n)*	Paper 105
Iofin, Natalia	*(n)*	Poster 110
Iordens, Git	*(n)*	Paper 129
Isefuku, Shuji	*(n)*	Paper 37
Israel, Heidi	*(n)*	BSFF Paper 11; Paper 92
Ito, Masayuki	*(n)*	Paper 37
Iwamoto, Masahiro	*(1-Clementia Pharm; 3B-Clementia Pharm; 9-Japanese Society for Cartilage Metabolism)*	BSFF Paper 25
Jackson, Kelly	*(3A; 4-Synthes)*	Paper 77
Jacobsen, Kimberly	*(n)*	BSFF Paper 11
Jacobson, Lance	*(n)*	Paper 93, 133
Jahangir, Amir	*(7-Springer; 9-Orthopaedic Trauma Association)*	Paper 102; Poster 5, 6, 17, 53, 54, 59, 69
Jain, Sudheer	*(n)*	Poster 4

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Jazini, Ehsan	*(n)*	Paper 61, 63; Poster 113
Jefferson, Laura	*(3A-Cook Medical)*	Paper 32
Jenkins, Mark	*(5-Synthes)*	Poster 31
Jeon, Oju	*(n)*	BSFF Paper 9
Jeray, Kyle J	*(3B-Zimmer; 5-Synthes; 8-Journal of Bone and Joint Surgery - American; Journal of Orthopaedic Trauma; 9-American Orthopaedic Association; Orthopaedic Trauma Association; Southeastern Fracture Consortium)*	Mini Symposium Faculty; Symposium II; FLOW Investigator
Jester, Adam	*(n)*	Paper 116
Ji, Youngmi	*(n)*	BSFF Paper 26
Jiang, Xie-Yuan	*(n)*	Paper 88
Johal, Herman	*(n)*	Poster 92
Johannesmeyer, David	*(n)*	Poster 47
Johnson, Aaron	*(3B-DJ Orthopaedics)*	Paper 67
Johnson, Daniel	*(n)*	Paper 102
Johnson, Joseph	*(n)*	Paper 81; Poster 50
Johnston, Geoffrey	*(n)*	Poster 22, 23
Johnstone, Alan	*(n)*	Paper 34
Jones, Clifford B	*(8-Journal of Bone and Joint Surgery - American; Journal of Orthopaedics and Traumatology; 9-Orthopaedic Trauma Association)*	Skills Lab Faculty; Mini Symposium Faculty; Case Presentation Faculty; Paper 69, 73, 86, 107; Poster 55; FLOW Investigator; METRC
Jones, Patrick	*(n)*	BSFF Paper 26
Jordan, Charles	*(3B-Advanced Orthopaedic Solutions)*	Paper 57
Joshi, Manjari	*(8-IDCP)*	Paper 104, 111
Kacena, Melissa	*(n)*	BSFF Paper 8

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DISCLOSURE LISTING – ALPHABETICAL

Kaimrajh, David	*(5-Advanced Orthopedic Solutions; Ellipse Medical Technologies; FxDevices; Miami Device Solutions; Synthes)*	BSFF Paper 19
Kain, Michael	*(9-New England Orthopaedic Society)*	Paper 98
Kakazu, Rafael	*(n)*	Paper 107; Poster 111
Kallyth, Sun	*(n)*	Paper 35
Kanakaris, Nikolaos	*(2-Biomet; DePuy, A Johnson & Johnson Company; Medtronic; Pfizer; Stryker; 3B-Biomet; Stryker; 8-"Open Access Trauma" of Open Access Publishing London "Hard Tissue" of Open Access Publishing London "Case Reports in Orthopedics" of Hindawi Publishing Corporation)*	Paper 72
Kandemir, Utku	*(2-AO North America; Stryker; 5-Biomet; Stryker; Synthes)*	Poster 123
Kang, Daniel	*(n)*	Poster 126, 129
Kang, Dong Hyun	*(n)*	Paper 100
Kaptein, Bart	*(n)*	Poster 37
Karam, Matthew	*(n)*	Paper 81; Poster 39
Kark, Jonathan	*(n)*	Paper 91
Karunakar, Madhav	*(8-Journal of Orthopaedic Trauma; 9-AAOS; Orthopaedic Trauma Association)*	Poster 91
Kates, Stephen	*(2-AO Foundation; 3B-Surgical Excellence; 7,8-Sage Publications; 9-AAOS; AO North America; AOTrauma; Orthopaedic Trauma Association)*	Poster 20
Kaufman, Adam	*(n)*	Paper 131
Kaufman, David	*(n)*	Poster 24
Kawakami, Ryouichi	*(n)*	Paper 37

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DISCLOSURE LISTING – ALPHABETICAL

Keding, Ada	*(n)*	Paper 32
Keene, David	*(n)*	Paper 31
Keener, Emily	*(n)*	Paper 105; Poster 47, 82
Kelly, Derek	*(2-Medtronic; 7-Elsevier Health; 9-Pediatric Orthopaedic Society of North America)*	Paper 52; Poster 76
Kempton, Laurence	*(n)*	Paper 48; Poster 65
Ketz, John	*(5-Biomimetic)*	Paper 123; Poster 20
Khemka, Aditya	*(n)*	Poster 29
Kim, Chang-Yeon	*(n)*	Poster 38
Kim, Ji-Wan	*(n)*	Poster 49
Kim, Joon-Woo	*(n)*	Paper 74; Poster 79
Kim, Jung-Jae	*(n)*	Poster 49
Kingsbury, Trevor	*(n)*	Paper 80
Kinney, Matthew	*(n)*	Paper 50
Kinsey, Tracy	*(5-Stryker; Arthrex; 8-Journal of Arthroplasty)*	Poster 125
Kleinhenz, Dominic	*(n)*	Poster 50
Kleis, Kevin	*(n)*	BSFF Paper 24
Kleweno, Conor P	*(n)*	Mini Symposium Faculty
Klinge, Stephen	*(n)*	Poster 50
Kluk, Matthew	*(n)*	Poster 127, 128
Kodumuri, Preetham	*(n)*	Poster 27
Koehler, Logan	*(n)*	Poster 119
Koerner, John	*(3A-Novartis; 5-Medtronic; 8-Journal of Spinal Disorders and Techniques)*	Poster 34
Kogut, Mathew	*(n)*	Poster 81
Koh, Eugene	*(3B-Biomet)*	Paper 61
Konda, Sanjit	*(8-American Journal of Orthopedics)*	Paper 41, 44, 47, 64, 82, 97, 124; Poster 14, 61, 62, 94, 100, 101, 115
Korley, Rob	*(n)*	Poster 52

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DISCLOSURE LISTING – ALPHABETICAL

Koster, Lennard	*(3A-Employee for RSAcore)*	Poster 37
Kottmeier, Stephen	*(n)*	Program Committee; Moderator; Case Presentation Faculty; Paper 107
Koury, Kenneth	*(n)*	Poster 80
Kovach, Stephen J III	*(2-Davol; 5-KCI)*	Mini Symposium Faculty
Koval, Kenneth	*(1-Biomet; 2-Biomet; Stryker; Orthofix; Acumed; Donjoy; 3B-Biomet; Stryker; Orthofix; Acumed; Donjoy; 5-Acumed; 7-Lippincott; 8-JOT)*	Skills Lab Faculty; Paper 130; Poster 122
Kramer, Patricia	*(n)*	Poster 9
Kreder, Hans	*(3B-Immediate family consultant for Synthes; 5-Synthes; Biomet; Zimmer; 7-Elsevier Publishing; AO North America; 9-Canadian Orthopaedic Association, AO Trustee)*	Mini Symposium Faculty; FLOW Investigator
Krettek, Christian	*(n)*	John Border, MD Memorial Lecturer; BSFF Paper 1, 2, 27, 43
Krieg, James C	*(1-SAM Medical; Synthes CMF; 2,3B-Synthes; 3B-Conventus; Medtronic; Merck; 4-Conventus; Domain Surgical; MDLive; Trice Medical; 8-Journal of the American Academy of Orthopaedic Surgeons)*	Mini Symposium Faculty
Kubiak, Erik	*(3B-DePuy, A Johnson & Johnson Company; DJ Orthopaedics; Tornier; Zimmer; 4-Connextions Medical, Inc.; OrthoGrid Technologies, Inc.; 5-Zimmer; 8-Journal of Orthopaedic Trauma; 9-Foundation for Orthopaedic Trauma)*	Skills Lab Leader; Skills Lab Faculty; BSFF Paper; Paper 16, 59, 93, 99, 128; Poster 18, 33, 133
Kuhn, Kevin	*(n)*	Paper 80; Poster 25, 30
Kumar, Abhishek	*(n)*	BSFF Paper 29

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Kuramoto, Lisa	*(n)*	Poster 40
Kutsikovich, Jeffrey	*(n)*	Paper 52
Kuzyk, Paul	*(3B-Avenir Medical Inc.; 5-Stryker; Zimmer)*	BSFF Paper 18
Kwiatkowski, Krzystztof	*(n)*	Paper 43
Kwon, John	*(1-Paragon 28; Trimed)*	Poster 1
Lack, William	*(n)*	Paper 56; Poster 19
Lafferty, Paul	*(8-Clinical Orthopaedics and Related Research; Journal of Bone and Joint Surgery - American; Journal of Orthopaedic Trauma)*	Poster 114; METRC
Laflamme, Georges-Yves	*(3B-Stryker)*	Paper 122, 126; Poster 3
Lall, Ranjit	*(n)*	Paper 31
Lamb, Sarah	*(n)*	Paper 31
LaMothe, Jeremy	*(n)*	Poster 48
Lane, Joseph M	*(3B-Bone Therapeutics, Inc. CollPlant; Grafty's; Harvest, Inc., ISTO, Biologics MD; 4-Dfine, CollPlant; 5-Merck; 9-Orthopaedic Research Society; Musculoskeletal Tumor Society; AAOS; Association of Bone and Joint Surgeons, AOA, ASBMR)*	Mini Symposium Faculty
Lang, Gerald	*(9-AAOS; Wisconsin Orthopedic Society)*	BSFF Symposium Faculty
Langford, Joshua	*(1-Advanced Orhopaedic Solutions; 2-Smith & Nephew; 3B-Stryker; 4-Core Orthopaedics; Institute for Better Bone Health, LLC)*	Poster 122
Lanier, Paul	*(n)*	Poster 119
LaPorte, Dawn	*(9-Committee Chair ASSH; Board Member RJOS; Ortho RRC Member)*	Poster 57

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Latta, Loren	*(3C-FxDevices, NuTek Orthopaedics, Sky Medical, MAKO Surgical, OrthoSensor, Miami Device Solutions; 5-Alphatec Spine; Medtronic Sofamor Danek; Stryker; Synthes; 7-Springer; Saunders/ Mosby-Elsevier; ASOP; 8-Journal of Orthopaedic Trauma; 9-Assoc. for the Rational Treatment of Fractures)*	BSFF Paper 19
Lawendy, Abdel-Rahman	*(n)*	BSFF Paper 28; Paper 33; Poster 51
Lawrie, Charles	*(n)*	Poster 12
Lazaro, Lionel	*(n)*	Paper 40; Poster 48
Le, Elizabeth	*(n)*	Paper 61
Leach, J. Kent	*(n)*	BSFF Paper 9
Leas, Daniel	*(n)*	Paper 107; Poster 99
Lebrun, Christopher	*(8-Journal of Bone and Joint Surgery - American; Journal of Orthopaedic Trauma; 9-Orthopaedic Trauma Association; Society of Military Orthopaedic Surgeons)*	Paper 71
Lebus, George	*(n)*	Poster 88
Leduc, Stéphane	*(2,3B-Stryker; 5-Amgen Co; DePuy, A Johnson & Johnson Company; Synthes; Stryker; Smith & Nephew; 6-Amgen Co; Eli Lilly; Norvartis; Sanofi-Aventis)*	Poster 3
Lee, Edwin	*(n)*	Poster 65
Lee, John	*(n)*	Paper 76; Poster 36
Lee, Mark A	*(2-AONA; 2,3B-Zimmer); 2,3B,5-Synthes; 6-Synthes Fellowship Support; 9-Orthopaedic Trauma Association)*	BSFF Symposium Moderator; Case Presentation Faculty; BSFF Paper 9
Leenen, David	*(n)*	Poster 42

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Leenen, Luke	*(n)*	Paper 118
Lefaivre, Kelly	*(5-Synthes; Zimmer)*	Paper 42
Lehman, Ronald	*(2-Medtronic, DePuy Spine, Stryker, Broadwater, St. Louis University (Practical Anatomy & Surgical Education); 3B-Medtronic; 8-Lippincott, Williams, & Wilkins; no financial relationship but serve in editorial capacity with The Spine Journal and Spine Deformity; 9-SRS - Program Committee Chair, IMAST Committee Chair Elect, CME Committee Chair, Education Committee, Awards and Scholarships Committee, Non-conflicted CME Committee, Conflict of Interest Review Panel; CSRS Program Chair, CME Committee Program Chair, Member Survey Committee, Scientific Program Committee; AOSpine Education Committee, Boards Prep Subcommittee, Faculty Development, Advanced Fellows Courses; NASS PCP Committee Chair, Governance Committee Chair, CME Committee, Section on Biologics & Basic Science, Program Committee, Conflict of Interest Review Committee*	Poster 126
Leighn, Tambre	*(n)*	Mini Symposium Faculty
Leighton, Ross	*(1,2-Zimmer; 2-Biomet; Stryker; 2,3B-Etex; 2,5,6-Synthes; 2,6-DePuy, A Johnson & Johnson Company; Smith & Nephew; 9-Canadian Orthopaedic Association; Innovision; Orthopaedic Trauma Association)*	OTA BOD; Paper 33, 86; Poster 15
Lenchik, Leon	*(n)*	Poster 77
Leong, Kwok-Sui	*(n)*	Paper 35

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DISCLOSURE LISTING – ALPHABETICAL

Leslie, Michael	*(2-DePuy, A Johnson & Johnson Company; 3B-Zimmer)*	Paper 78; Poster 38
Leucht, Philipp	*(9-AAOS Biological Implants Committee)*	Paper 124; Poster 14, 61, 100, 115
Lewandowski, Louis	*(9-Society of Military Orthopaedic Surgeons)*	Poster 127, 128, 130
Leyes Vence, Manuel	*(n)*	Paper 43
Liew, Susan	*(n)*	FLOW Investigator
Li, Ting	*(n)*	Paper 88
Li, Yuneng	*(n)*	Paper 88
Liew, Allan	*(4-Johnson & Johnson; 5-Synthes)*	BSFF Paper 14; Paper 33
Lim, Philip	*(n)*	Poster 34
Linn, Michael	*(n)*	Paper 50; Poster 13
Liporace, Frank	*(1,2,3B-Biomet; 2-Stryker; 2,3B-Synthes; 3B-Medtronic; Stryker; 3C-AO)*	Skills Lab Faculty; Paper 75; Poster 32, 34, 94
Litrenta, Jody	*(n)*	BSFF Paper 12
Little, Milton	*(n)*	Poster 9, 81
Loewenthal, Mark	*(n)*	Paper 108
Loftus, Michael	*(n)*	Paper 49, 89
Lombardi, Joseph	*(n)*	Poster 134
Longoria, Michael	*(n)*	Poster 24
Lord, Sarah	*(n)*	Poster 29
Lorich, Dean G	*(n)*	Moderator; Case Presentation Faculty; BSFF Paper 15; Paper 40, 46, 49, 89; Poster 41, 48
Lotzien, Sebastian	*(n)*	Poster 26
Louati, Hakim	*(n)*	BSFF Paper 14
Lowe, Jason	*(2-Synthes; 3B-Acumed, LLC; 5-Stryker; Synthes)*	Moderator; BSFF Paper 19; Paper 105; Poster 47, 82
Lübbeke, Anne	*(n)*	Poster 43

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Lucas, Robert	*(n)*	Poster 1
Ludwig, Steven	*(2-DePuy; Synthes; 3B-DePuy;Globus Medical; K2Medical; Synthes; 4-ASIP; ISD; 5-AO Spine North America Spine Fellowship Suppport; Globus Medical; 7-DePuy; Thieme, QMP; 8-Journal of Spinal Disorders and Techniques; The Spine Journal; Contemporary Spine Surgery; 9-Cervical Spine Research Society)*	Paper 61
Lukasiewicz, Adam	*(n)*	Paper 78, 103; Poster 56, 66, 98
Luks, Howard	*(3B-Curely; Rotation Medical; Vidscrip.com)*	Mini Symposium Faculty
Lybrand, Kyle	*(n)*	Paper 98; Poster 78
Lyon, Tom	*(3B-Kuros Biotech, Inc)*	Paper 43
Ma, Baotong	*(n)*	Paper 95
Maceroli, Michael	*(n)*	Paper 123; Poster 16
Macke, Christian	*(n)*	BSFF Paper 1
MacLeod, Mark	*(n)*	Paper 33
Madey, Steven	*(1,3C-Zimmer; Synthes)*	BSFF Paper 10
Madsen, Jan Erik	*(n)*	Paper 68
Magyari, Zoltan	*(n)*	Paper 43
Mahan, Susan	*(n)*	Paper 53
Mahmood, Bilal	*(n)*	Poster 16
Mäkinen, Tatu	*(n)*	BSFF Paper 18
Malm, Peter	*(n)*	Poster 99
Maloney, Michael	*(2-Arthrex; 3B-Arthrex; 4-Telephus Medical; 8-Editorial Board AJSM; 9-Chair, Traveling Fellowship Committee AOSSM)*	Paper 121

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DISCLOSURE LISTING – ALPHABETICAL

Mamczak, Christian N	*(2-AO North America; 2,3B-Smith & Nephew; 7-Springer; 9-AOAO-Trauma Section Secretary; Orthopaedic Trauma Association)*	Skills Lab Faculty; Mini Symposium Faculty
Mangan, Katharine	*(n)*	Paper 80
Manoli, Arthur	*(1-DJO Global; 2-Stryker; Synthes; 6-Synthes; 8-Foot and Ankle International; 9-Michigan Orthopaedic Society)*	Paper 47, 97
Manson, Theodore T	*(1,3B-Stryker; 8-Journal of Arthroplasty; 9-AAOS; American Association of Hip and Knee Surgeons)*	Symposium Moderator; Paper 67, 71; Poster 92, 93
Marcantonio, Andrew	*(n)*	Paper 98; Poster 106
Marchand, Lucas	*(n)*	Paper 59, 93, 128; Poster 133
Marecek, Geoffrey S	*(9-AAOS)*	Skills Lab Faculty
Marien, Mélissa	*(n)*	Poster 3
Marquez-Lara, Alejandro	*(n)*	Mini Symposium Faculty
Marsh, J Lawrence	*(1-Tornier; Oxford University Press; 5-NIH; DOD; OMeGA; NBME; ABOS; OTA; 9-President ABOS)*	Paper 48; Poster 39; METRC
Martin, Adam	*(n)*	Poster 85
Martin, Ryan	*(n)*	Poster 52
Mathevon, Henry	*(n)*	Paper 43
Mauffrey, Cyril	*(3C-Stryker; 6-Abbott; Depuy-Synthes; AO Foundation)*	Moderator
Maxson, Benjamin	*(n)*	Paper 112
McAndrew, Christopher	*(2-Synthes; 7-Journal of Bone and Joint Surgery - American)*	Paper 84, 87, 90; Poster 13, 103
McBride, Chris	*(n)*	Mini Symposium Faculty
McCarroll, Tyler	*(n)*	Paper 79; Poster 90
McClure, Philip	*(n)*	Poster 50

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McCusker, Michael	*(n)*	Paper 111
McDaniel, Jennifer	*(n)*	BSFF Paper 20
Mcdonald, Daniel	*(n)*	BSFF Paper 5
McHenry, Timothy	*(n)*	Poster 105
McKee, Michael D	*(1-Elsevier Inc; Stryker; 3B-Acumed, LLC; Olympus Biotech; Synthes; Zimmer; 5-Olympus Biotech; Wright Medical Technology, Inc.; Zimmer; 7-Springer; Wolters Kluwer Health - Lippincott Williams & Wilkins; 8-Journal of Orthopaedics and Traumatology; 9-American Shoulder and Elbow Surgeons; Orthopaedic Trauma Association; Canadian Orthopaedic Association)*	Program Committee; Moderator; Symposium Moderator; Mini Symposium Moderator; Mini Symposium Faculty; Case Presentation Faculty; Skills Lab Leader; Poster Tour Guide; Paper 96
McKinley, Todd O	*(3B-Bioventus; 9-Orthopaedic Trauma Association)*	Basic Science Committee; BSFF Moderator; BSFF Symposium Moderator; BSFF Paper 8; Paper 48, 79; Poster 65, 90; METRC
McQueen, Margaret	*(7,8-Wolters Kluwer Health - Lippincott Williams & Wilkins)*	Paper 30
Mehta, Devan	*(n)*	Poster 62
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)*	Mini Symposium Moderator; Case Presentation Moderator; Poster 73
Melbourne, Craig	*(n)*	Poster 17
Ménard, Jérémie	*(n)*	Paper 122, 126
Messmer, Peter	*(n)*	Paper 43

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DISCLOSURE LISTING – ALPHABETICAL

Meulenkamp, Brad	*(n)*	Poster 52
Meyer, Darlene A	*(n)*	OTA Staff
Miyamoto, Takashi	*(2-AOTrauma Japan; Zimmer Biomet)*	Paper 37
Michelier, Patrick	*(n)*	Poster 28
Miclau, Theodore III	*(3B-Acelity; Amgen Co; 5-Baxter; Synthes; 9-Inman Abbott Society; Orthopaedic Research Society; Orthopaedic Trauma Association; Osteosynthesis and Trauma Care Foundation)*	OTA President; METRC
Miller, Anna	*(3B-DePuy, A Johnson & Johnson Company)*	Paper 69, 107; Poster 77, 99; METRC
Miller, Brian	*(2-Smith & Nephew)*	Paper 77
Miller, Timothy	*(n)*	Poster 1
Milne, Edward	*(4-Pfizer; Stryker; 5-Synthes; Advanced Orthopedic Solutions; Medtronic; Sofamor; Danek; 6-Ellipse Technologies;*	BSFF Paper 19
Min, William	*(n)*	Skills Lab Faculty
Mir, Hassan R	*(3B-Acumed, LLC; Smith & Nephew; 4-Core Orthopaedics; 8-Journal of Orthopaedic Trauma Associate Editor; OsteoSynthesis, The JOT Online Discussion Forum Editor; OTA Newsletter Editor; 9-AAOS Council on Advocacy; AAOS Diversity Advisory Board; FOT Nominating and Membership Committees; OTA PR Committee)*	Skills Lab Faculty; Mini Symposium Moderator; Symposium Faculty; Paper 38, 70, 102, 113; Poster 5, 6, 17, 53, 54, 59, 69
Miranda, Alejandro	*(n)*	Poster 12
Mirza, Amer Jawad	*(3C-Seattle Information Systems; Acumed, LLC)*	Skills Lab Faculty

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Mistry, Dipesh	*(n)*	Paper 31
Mogami, Atsuhiko	*(n)*	Paper 37
Mohanty, Khitish	*(n)*	Paper 43, 72
Momaya, Amit	*(n)*	Poster 47
Mommsen, Philipp	*(n)*	BSFF Paper 1
Monazzam, Shafagh	*(n)*	Poster 64
Montanez, Elvira	*(n)*	Paper 43
Montero-Lopez, Nicole	*(n)*	Poster 132
Moody, Chris	*(n)*	Mini Symposium Faculty
Mun, Jong-Uk	*(n)*	Poster 79, 89, 95, 97
Moore, Sharon M	*(n)*	OTA Staff
Moore, Willard	*(n)*	BSFF Paper 19
Mora, Steven	*(n)*	Mini Symposium Faculty
Moran, Christopher	*(2-Smith & Nephew)*	Paper 101; Poster 27
Morellato, John	*(6-Arthrex; Synthes)*	BSFF Paper 14
Morison, Zachary	*(n)*	Paper 96
Mormino, Matt	*(3B-Cardinal Health; 8-Journal of the American Academy of Orthopaedic Surgeons, Journal of Surgical Education; 9-Mid America Orthopaedic Association)*	Case Presentation Faculty
Morris, Shane	*(n)*	Poster 106
Morshed, Saam	*(3B-Microbion Corporation; 5-Philips; 9-Orthopaedic Research Society; Orthopaedic Trauma Association)*	Paper 48
Morwood, Michael	*(n)*	Poster 99
Mulligan, Michael	*(n)*	Paper 71
Mullis, Brian H	*(2,3B; 9-Orthopaedic Trauma Association)*	Skills Lab Faculty; Case Presentation Faculty; Paper 69, 73, 86, 107
Munro, Christopher	*(n)*	Paper 34
Munz, John	*(2-Synthes)*	Poster 87

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DISCLOSURE LISTING – ALPHABETICAL

Murthi, Sarah	*(n)*	Paper 111
Nagle, David	*(n)*	Paper 50
Nam, Julian	*(n)*	Paper 31
Napora, Joshua	*(n)*	Paper 119, 120
Narayanan, Arvind	*(n)*	Poster 89
Nascone, Jason	*(1-Synthes; 2-Smith & Nephew; Synthes; 3B-IMDS; Smith & Nephew; 8-Journal of Orthopaedic Trauma; 9-AONA; Orthopaedic Trauma Association)*	Mini Symposium Moderator; BSFF Paper 12; Paper 55, 71
Natoli, Roman	*(n)*	Poster 19
Nault, Marie-Lyne	*(n)*	Poster 3
Nauth, Aaron	*(5-Capital Sports Entertainment; Synthes, Stryker; Sonoma Orthopaedics)*	BSFF Moderator; Basic Science Committee; BSFF Symposium Faculty; Symposium Faculty; Mini Symposium Faculty; Case Presentation Faculty; Paper 96
Nelissen, Rob	*(3B-ZimmerBiomet; 9-Netherlands Orthopaedic Association)*	Poster 37
Nerlich, Michael L	*(n)*	Guest Nation Presenter
Nesti, Leon	*(9-Orthopaedic Research Society; American Society for Surgery of the Hand)*	BSFF Paper 26
Neuhaus, Valentin	*(n)*	Paper 125
Neunaber, Claudia	*(n)*	BSFF Paper 1, 2, 27
Nguyen, Joseph	*(n)*	Poster 41
Nicholas, Desy	*(n)*	Poster 52
Nicholson, Nathan	*(n)*	Poster 39
Nikkel, Lucas	*(n)*	Poster 16
Noack, Sandra	*(n)*	BSFF Paper 2
Noback, Peter	*(n)*	Poster 134

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Nork, Sean	*(2-Depuy Synthes, AONA; 3B-Depuy Synthes)*	Paper 69
Norris, Brent L	*(1-Norris Surgical, LLC; 3B-DePuy Synthes; Acumed; 5-AO-Trauma North America; 9-Orthopaedic Trauma Association)*	BSFF Symposium Moderator; BSFF Symposium Faculty
O'Brien, Peter	*(2,3B-Zimmer; 5-DePuy, A Johnson & Johnson Company; Synthes; Zimmer; 8-Journal of Orthopaedic Trauma)*	Paper 42
O'Daly, Brendan	*(n)*	Paper 71
O'Halloran, Kevin	*(n)*	Paper 55
O'Toole, Robert V	*(3B-iMDS; Smith & Nephew; 5-Synthes; Stryker; 9-Orthopaedic Trauma Association)*	OTA BOD; Program Committee; Moderator; Symposium Faculty; Case Presentation Faculty; BSFF Paper 12; Paper 55, 67, 71, 104, 107, 111, 116, 131; Poster 60, 92, 93, 104, 118; METRC
Obakponovwe, Oghofori	*(n)*	Paper 72
Obara, Shu	*(n)*	Paper 37
Obremskey, William T	*(9-Orthopaedic Trauma Association; Southeastern Fracture Consortium)*	Symposium Moderator; Mini Symposium Faculty; Paper 102; Poster 5, 6, 17, 53, 54, 59, 69, 70; METRC
Ogburn, Charles	*(n)*	Poster 125
Oh, Chang-Wug	*(2,5-Synthes; 3C-Zimmer)*	Paper 74; Poster 49, 79
Oh, Jong-Keon	*(n)*	Paper 74; Poster 79
Oladeji, Lasun	*(n)*	Poster 47
Olewicz, Simon	*(n)*	Poster 27
Oliphant, Bryant	*(2-Synthes; 4-PersonalRN)*	Poster 85
Olson, Jeffrey	*(n)*	Poster 121, 124
Olson, Joshua	*(n)*	Poster 114

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DISCLOSURE LISTING – ALPHABETICAL

Olson, Steven A	*(5-Synthes; 9-Orthopaedic Trauma Association; Southeastern Fracture Consortium)*	OTA BOD; BSFF Symposium Faculty; Mini Symposium Moderator; Paper 45
Orapiriyakul, Wich	*(2-Endowment Fund; Faculty of Medicine; Chiang Mai University; 3A-Faculty of Medicine; Prince of Songkhia University, Thailand)*	BSFF Paper 22
Ortega, Gilbert R	*(2,3B-Smith & Nephew)*	Program Committee; Moderator; Skills Lab Faculty; Paper 77
Osgood, Greg	*(2-Bioventus, Inc.; 3B-Lilly; 3B,5-Smith & Nephew; Synthes; Stryker; 8-Journal of Orthopaedics and Traumatology; 9-Orthopaedic Trauma Association; Foundation for Orthopaedic Trauma)*	Poster 57
Osterhoff, Georg	*(n)*	Paper 42
Ostrum, Robert F	*(3B-Bioventus; 7-SLACK Incorporated; 8-Clinical Orthopaedics and Related Research; Journal of Orthopaedics and Traumatology; 9-Orthopaedic Trauma Association)*	Case Presentation Faculty; Paper 73
Owen, Matthew	*(n)*	Paper 105
Owens, Johnny	*(n)*	Poster 8
Pace, Antonio	*(n)*	Paper 43
Pacifici, Maurizio	*(3B-Clementia Pharmaceuticals)*	BSFF Paper 25
Paksima, Nader	*(2,3B-Stryker; 8-Bulletin of the Hospital for Joint Diseases)*	Poster 112, 120, 132
Pallister, Ian	*(n)*	Paper 31
Palmer, Robert	*(n)*	Poster 122
Pant, Bhaskar Raj	*(n)*	Skills Lab Faculty
Pape, Hans-Christoph	*(n)*	Paper 73

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Papp, Steven R	*(2-Stryker; 5-Synthes)*	BSFF Symposium Faculty; BSFF Paper 14; Paper 33; FLOW Investigator
Park, Ki-Chul	*(n)*	Poster 49
Park, Kyeong-Hyeon	*(n)*	Paper 74
Paryavi, Ebrahim	*(n)*	Paper 63, 116; Poster 104, 113
Patel, Amratial	*(n)*	Paper 43
Patel, Karan	*(n)*	Paper 97
Patel, Neeraj	*(n)*	Poster 32
Patel, Stuti	*(n)*	Poster 102
Patterson, Brendan	*(n)*	OTA BOD; METRC
Patton, Andrew	*(n)*	BSFF Paper 4
Patton, Daniel	*(n)*	Paper 91
Pavey, Gabriel	*(n)*	BSFF Paper 25
Pean, Christian	*(n)*	Paper 41, 44, 82; Poster 4; 14; 101, 109, 115
Pellegrini, Vincent	*(1,3B-DePuy, A Johnson & Johnson Company; 9-ACGME RRC in Orthopaedic Surgery; Association of American Medical Colleges, Board of Directors; Council of Faculty and Academic Societies, AAMC - Chair-Elect and Administrative Board; Health Volunteers Overseas/ Orthopaedics Overseas, Board of Directors; Hip Society; South Carolina Orthopaedic Association)*	BSFF Paper 5
Pelsser, Vincent	*(n)*	Poster 3
Pennock, Andrew	*(n)*	Paper 50; Poster 74, 75
Penny, Phillip	*(n)*	Poster 2

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DISCLOSURE LISTING – ALPHABETICAL

Pensy, Raymond A	*(n)*	Moderator; Mini Symposium Moderator; Paper 131
Perdue, Aaron M	*(n)*	Skills Lab Faculty
Perez, Brandon	*(n)*	BSFF Paper 4
Perez, Ed	*(2-Smith & Nephew; Zimmer; 3B-Biomet; Cardinal Health; 4-Bristol-Myers Squibb; Pfizer; Stryker; 7-Saunders/Mosby-Elsevier; 9-Orthopaedic Trauma Association)*	Paper 38, 73
Perreault, Alexander	*(n)*	Poster 23
Peters, Henning	*(n)*	BSFF Paper 1
Petrisor, Brad	*(2,3B,5-Stryker; 5-Zimmer; 6-Pfizer)*	FLOW Investigator
Phelps, Kevin	*(n)*	Poster 58
Phelps, Michelle	*(n)*	Poster 58
Phieffer, Laura	*(9-AAOS)*	Paper 73, 86
Phillips, Caleb	*(n)*	Paper 65
Piltz, Stefan	*(n)*	Paper 43
Podeszwa, David A	*(9-Pediatric Orthopaedic Society of North America; AAOS)*	Case Presentation Moderator; Paper 51
Pohl, Anthony	*(n)*	Paper 43
Polga, David J	*(2-Synthes)*	Skills Lab Faculty
Polinder, Suzanne	*(n)*	Paper 129
Pollak, Andrew	*(1-Zimmer; 5-Smith & Nephew; 7-AAOS; 9-National Trauma Institute)*	Paper 73, 95; METRC
Potter, Benjamin	*(8-Clinical Orthopaedics and Related Research; Journal of Orthopaedic Trauma; Journal of Surgical Orthopaedic Advances; 9-Society of Military Orthopaedic Surgeons; AAOS (BOS - SOMOS - research))*	BSFF Paper 25; Poster 129

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Pradhan, Saju	*(n)*	Skills Lab Faculty
Prasarn, Mark	*(2-DePuy, A Johnson & Johnson Company; Eli Lilly)*	Paper 62; Poster 87
Presson, Angela	*(n)*	Paper 93
Probe, Robert A	*(2-Stryker; Synthes); 3B-Stryker; 8-Journal of Bone and Joint Surgery - American; Journal of the American Academy of Orthopaedic Surgeons,Journal of Orthopaedic Trauma,Journal of Trauma; 9-Orthopaedic Trauma Association,Scott & White HealthCare,Scott & White Memorial Hospital)*	Mini Symposium Faculty
Pugliano, Vito	*(n)*	Poster 106
Puloski, Shannon	*(n)*	Poster 52
Purcell, Richard	*(n)*	Poster 127, 128, 129
Putnam, Sara	*(n)*	Paper 90; Poster 13
Qadir, Rabah	*(n)*	Paper 104
Quinnan, Stephen	*(3B-Smith & Nephew; Orthofix, Inc.; 3B, 5-DePuy, A Johnson & Johnson Company)*	Poster 96
Qureshi, Ammar	*(1-Zimmer; 2-Globus Medical; Medtronic Sofamor Danek; Stryker; 3B-Stryker; Zimmer; Medtronic; Orthofix, Inc.; 8-Clinical Orthopaedics and Related Research; Contemporary Spine Surgery; Global Spine Journal; Spine (reviewer); Spine Journal (reviewer); 9-AAOS; Cervical Spine Research Society; Musculoskeletal Transplant Foundation; NASS)*	BSFF Paper 25
Raschke, Michael	*(n)*	Paper 43
Radley, Joseph	*(n)*	Paper 65
Radwan, Zayde	*(n)*	Paper 62

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Rahim, Reza	*(n)*	Paper 108
Ramoutar, Darryl	*(n)*	Poster 27
Rando, Angelo	*(n)*	Paper 43
Rangan, Amar	*(2-Depuy LTD; 3B-Licence Fee JRI Limited, UK and Europe; 8-Shoulder & Elbow; 9-British Elbow & Shoulder Society; British Orthopaedic Association)*	Paper 32
Refaat, Motasem	*(n)*	BSFF Paper 9
Rehman, Saqib	*(2-Synthes; 7-Jaypee Medical Publishing; 8-Orthopedic Clinics of North America; 9-Orthopaedic Trauma Association)*	Mini Symposium Faculty
Reilly, Mark	*(2,3B-Stryker)*	Poster 80
Reisman, William	*(n)*	Paper 114; Poster 125
Rhorer, Anthony	*(1-ITS GmbH; 2-ITS; Smith and Nephew; 3B-ITS; Smith and Nephew; 5-Smith and Nephew; 8-Journal of Orthopaedics and Traumatology)*	Paper 77
Ricci, William M	*(1,3B,5-Smith & Nephew; 1-Wright Medical Technology, Inc.; 3B-Biomet; Stryker; 5- Synthes; 7-Journal of Bone and Joint Surgery - American; Wolters Kluwer Health - Lippincott Williams & Wilkins; 8-Journal of Orthopaedic Trauma; Wolters Kluwer Health - Lippincott Williams & Wilkins; 9-Orthopaedic Trauma Association, American Orthopaedic Association)*	OTA BOD; BSFF Symposium Faculty; BSFF Paper 12; Paper 73, 84, 87, 90; Poster 13, 103
Riccio, Anthony I	*(5-Synthes; 9-Pediatric Orthopaedic Society of North America)*	Case Presentation Faculty; Paper 51

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Ring, David C	*(1-Biomet; Medartis; Skeletal Dynamics; Wright Medical Technology, Inc.; 3B-Acumed, LLC; Biomet); 4-Illuminos; 8-Clinical 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)*	Symposium Faculty; Case Presentation Faculty; Paper 83, 125
Roberts, Craig S	*(7-Skeletal Trauma royalties from Elsevier; External Fixation royalties from Elsevier; 8-Injury (Deputy Editor); Journal of Orthopaedic Trauma (Editorial Board); 9-Mid-America Orthopaedic Association; Orthopaedic Trauma Association)*	Mini Symposium Faculty
Roberts, Justin	*(n)*	Paper 77
Roberts, Zachary	*(4-Pfizer)*	Paper 69; METRC
Robinson, Juan De Dios	*(n)*	Poster 15
Rocchi, Vanna	*(n)*	Poster 30
Rodericks, Deirdre	*(n)*	Poster 78
Rodrigues, Jeremy	*(n)*	Poster 27
Rodrigues, Terrance	*(n)*	Poster 31
Rodriguez, Edward	*(1-Zimmer; 3B-MXO; 4-MXO Orthopedics; 5-Synthes)*	Poster 44
Romero, Michelle	*(n)*	Paper 111
Roocroft, Joanna	*(n)*	Poster 74
Rosenbaum, Samuel	*(n)*	Paper 76; Poster 36

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Rosenwasser, Melvin	*(1-Biomet; 3B-Stryker; 4-CoNexions; Radicle Orthopedics; 8-American Journal of Orthopedics; 9-Foundation for Orthopedic Trauma)*	Poster 134
Roskosky, Mellisa	*(n)*	Poster 125
Rossi, Luciano	*(n)*	BSFF Paper 3
Rossiter, Nigel	*(6,7-AO; 9-Orthopaedic Trauma Society; OrthoISIS Medical Indemnity (Director); RossiterHadfield Medical Education (Director))*	Paper 32
Rothberg, David	*(n)*	BSFF Symposium Faculty; Paper 59, 93, 99, 128; Poster 18, 33, 133
Rotunno, Giuliana	*(n)*	Poster 60, 118
Rouleau, Dominique	*(2-Bioventus; Smith & Nephew; 5-DePuy, A Johnson & Johnson Company; KCI; Smith & Nephew; Stryker; Synthes; Zimmer; Tornier; 6-Arthrex, Inc; Smith & Nephew; Tornier; 8-OTSR-Elsevier)*	Paper 122, 126; Poster 3
Roussignol, Xavier	*(n)*	Paper 43
Routt, Milton L 'Chip'	*(2-AONA; Zimmer)*	Mini Symposium Faculty
Rozbruch, S	*(1,3B-Small Bone Innovations; 1,2,3B-Smith & Nephew; 2,3B-Ellipse Technologies Inc.; Stryker; 7-Informa; Springer; 9-Limb Lengthening Reconstruction Society)*	Paper 58
Ruland, Christopher	*(n)*	Paper 116

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Russell, George V	*(2-AONA - Honoraria for courses; 4-SMV; Zimmer, Stock Options, < 5%; Zimmer; 5-Synthes, Research Support, Salary support for research manager; METRC, research support; 9-AAOS; Orthopaedic Trauma Association)*	Mini Symposium Faculty; METRC
Russell, Thomas A (Toney)	*(1-Smith and Nephew; 3A-Innovsion; 3B-Zimmer; 4- CelegenTek; ETEX; Innovision; 6-Skeletal Kinetics; CeleganTek; Zimmer; 7- Wolters Kluwer Health-Lippincott Williams & Wilkins; 9-American Orthopaedic Assoc)*	BSFF Symposium Faculty
Ryan, Devon	*(n)*	Poster 110
Ryan, Scott	*(n)*	Poster 106
Sabharwal, Samir	*(n)*	Paper 58
Safir, Oleg	*(3B-Intellijoint)*	BSFF Paper 18
Sagara, Mitustoshi	*(n)*	Paper 37
Sagi, H Claude	*(1,2,3B,5-Stryker; 2,3B- Synthes; 2,3B,5-Smith & Nephew; 8-Journal of Orthopaedic Trauma; 9-Orthopaedic Trauma Association)*	Mini Symposium Faculty; Case Presentation Faculty; BSFF Paper 17; Paper 57, 73, 112, 117
Sakai, Kensuke	*(n)*	Paper 37
Salcedo, Edgardo	*(n)*	Poster 64
Samuel, Andre	*(n)*	Paper 78, 103; Poster 56, 66, 98
Sancheti, Parag	*(n)*	FLOW Investigator
Sanchez, Carlos	*(n)*	Paper 106
Sancineto, Carlos	*(n)*	BSFF Paper 3
Sandberg, Benjamin	*(n)*	Poster 114

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Sanders, David W	*(3B-Smith and Nephew Richards; 5-Smith and Nephew Richards; 6-Journal of Orthopedic Trauma; 9-Orthopaedic Trauma Association)*	Program Committee; Moderator; BSFF Symposium Faculty; Skills Lab Faculty; BSFF Paper 28; Paper 33, 107; Poster 51
Sanders, Drew	*(n)*	Paper 57
Sanders, Roy	*(1-Stryker; 1,3B-Biomet; CONMED Linvatec; Smith & Nephew; 5-Health and Human Services; National Institutes of Health (NIAMS & NICHD; Medtronic; Smith & Nephew; Stryker, METRC (DOD), Orthopaedic Trauma Association; 7-Journal of Orthopaedic Trauma; 8-Journal of Orthopaedic Trauma; Orthopedics Today; 9-Orthopaedic Trauma Association)*	BSFF Symposium Faculty; BSFF Paper 12; Paper 117; Poster 35; METRC
Sands, Andrew	*(2,3B,5-Synthes; 4-Amgen Co; Pfizer; 7-Saunders/Mosby-Elsevier; 9-AO)*	Poster 2
Santoni, Brandon	*(n)*	BSFF Paper 17
Saper, David	*(n)*	Paper 98
Sapienza, Anthony	*(n)*	Poster 132
Sathiyakumar, Vasanth	*(n)*	Paper 102; Poster 54, 70
Sauro, Gina	*(n)*	Paper 40
Sawyer, Jeffrey	*(7-Mosby; Wolters Kluwer Health - Lippincott Williams & Wilkins; 9-AAOS; Pediatric Orthopaedic Society of North America; Campbell Foundation)*	Paper 52, 113; Poster 76
Scarcella, Nicholas	*(n)*	Paper 39
Schäck, Luisa	*(n)*	BSFF Paper 2
Schaller, Thomas	*(2-Smith & Nephew)*	Poster 105
Scharfenberger, Angela	*(n)*	Poster 67

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Schemitsch, Emil H	*(1,3B,6-Stryker; 3B-Acumed, LLC; Celgene; Sanofi-Aventis; 3B,5,6-Smith & Nephew; 6-Canadian Institutes of Health Research (CIHR); OMEGA; Zimmer; Synthes; 7-Saunders/Mosby-Elsevier; 8-Journal of Orthopaedic Trauma; 9-Orthopaedic Trauma Association; Canadian Orthopaedic Association; Osteosynthesis and Trauma Care Foundation)*	Basic Science Committee; BSFF Symposium Moderator; BSFF Symposium Faculty; Symposium Faculty; Mini Symposium Moderator; Mini Symposium Faculty; Case Presentation Moderator; Paper 35, 96; FLOW Investigator
Schenker, Mara	*(n)*	Paper 91
Schense, Jason	*(3A,4-Kuros Biosurgery)*	BSFF Paper 6; Paper 43
Schep, Niels	*(3B-Synthes; 7-Bohn Stafleu)*	Paper 129; Poster 131
Schiff, Adam	*(3B-Stryker)*	Poster 19
Schiffman, Brett	*(n)*	Paper 56
Schildhauer, Thomas	*(2-Aesculap/B.Braun; Bayer-HealthCare; Stryker; 8-Journal of Orthopaedic Trauma)*	Poster 26
Schipper, I.B.	*(n)*	Poster 37
Schlechter, John	*(2-Arthrex)*	BSFF Paper 24
Schmidt, Andrew	*(3B-Acumed, LLC; Bone Support AB; St. Jude Medical; 3C-Twin Star Medical; Conventus Orthopaedics; 4-Conventus Orthopaedics; Epien; Epix VAN; International Spine and Orthopaedic Instititute; Twin Star Medical; 7-Thieme, Inc.; 8-Journal of Bone and Joint Surgery - American; Journal of Orthopaedic Trauma; Journal of Knee Surgery; 9-Orthopaedic Trauma Association)*	OTA BOD; Mini Symposium Faculty; Paper 69, 73; METRC
Schneider, Prism	*(n)*	Paper 62
Schottel, Patrick	*(n)*	BSFF Paper 15; Paper 49, 89

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DISCLOSURE LISTING – ALPHABETICAL

Schröter, Christian	*(n)*	BSFF Paper 1
Schubert, Manuel	*(n)*	Paper 76; Poster 36
Schultz, Robert S	*(n)*	Skills Lab Faculty
Schwartz, Alexandra	*(2-Synthes; 3A,4-spouse employed by zimmer; Zimmer)*	Paper 50
Sciadini, Marcus F	*(2-Synthes; 3A,4-spouse employed by zimmer; Zimmer)*	Case Presentation Moderator; Paper 71, 111; Poster 60, 118
Scolaro, John Alan	*(n)*	Skills Lab Leader
Scott, Aaron T	*(8-Arthroscopy; Journal of Surgical Orthopaedic Advances)*	METRC
Sebastian, Christina	*(n)*	Poster 60, 118
Seigerman, Daniel	*(n)*	Poster 34
Seligson, David	*(3B-Stryker; 7-Springer)*	BSFF Paper 21
Sems, Stephen	*(1,3B-Biomet)*	Paper 73; Poster 45
Serrano-Riera, Rafael	*(n)*	Paper 57, 112, 117; Poster 35
Service, Ben	*(n)*	Paper 130; Poster 122
Sethi, Anil	*(n)*	Poster 85
Sethi, Manish	*(n)*	Paper 102; Poster 5, 6, 17, 53, 54, 59, 69, 70
Seymour, Rachel	*(n)*	Paper 85; Poster 58
Shaath, Mohamad	*(n)*	Poster 80
Shachter, Ross	*(n)*	Poster 24
Shaffer, Andre	*(n)*	Paper 46
Shah, Adil	*(n)*	Poster 21
Shah, Ali	*(n)*	Paper 101
Shannon, Steven	*(n)*	Poster 45
Shaw, David	*(n)*	Paper 72
Shearer, David	*(n)*	Poster 84
Sheean, Andrew	*(n)*	Poster 8
Sheehan, Katie	*(n)*	Poster 40

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Sheikh, Zeeshan	*(n)*	BSFF Paper 29
Shields, Edward	*(n)*	Paper 121, 123
Shiels, Stefanie	*(n)*	Paper 106
Shimota, Megan	*(n)*	Paper 107
Shirahama, Masahiro	*(n)*	Paper 37
Shiu, Brian	*(6-Synthes)*	Paper 61
Short, Adam	*(n)*	BSFF Paper 21
Shuler, Michael	*(1,2,6-Nonin Medical, Inc; 3B-CastLight)*	Poster 125
Siegel, Jodi A	*(n)*	Skills Lab Faculty; Case Presentation Faculty; Paper 73
Sielatycki, John	*(n)*	Paper 113
Sierra, Rafael	*(n)*	Poster 45
Sietsema, Debra	*(2,3B-Eli Lilly; 9-American Orthopaedic Association; National Association of Orthopaedic Nurses; National Osteoporosis Foundation)*	Mini Symposium Faculty; Poster 55
Simpson, Robert	*(n)*	Poster 46
Sims, Laura	*(n)*	Poster 22
Sims, Stephen H	*(2-Stryker)*	Case Presentation Faculty

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DISCLOSURE LISTING – ALPHABETICAL

Singh, Kern	*(1-Zimmer; Stryker, Pioneer; 3B-DePuy; Zimmer; Stryker; Globus; 7-Lippincott; Thieme; Jaypee Publishing; Stack Publishing; 8-Journal of Contemporary Spine Surgery; Journal of Spine Disorders & Techniques; ISRN Orthopedics; Spine Surgery Today; Journal of Minimally Invasive Orthopedics; World Journal of Orthopedics; Annuals of Translational Medicine; 9-Cervical Spine Research Society; Indian American Spine Alliance; AAOS Spine Program Committee)*	Poster 56
Sirkin, Michael	*(1,2,3B-Biomet; 7-Saunders/ Mosby-Elsevier; 8-Journal of the American Academy of Orthopaedic Surgeons, Journal of Trauma; Journal of Orthopaedics and Traumatology; 9-Orthopaedic Trauma Association)*	Poster 80
Slobogean, Gerard P	*(8-Journal of Orthopaedic Trauma; 9-Orthopaedic Trauma Association)*	Program Committee; BSFF Symposium Faculty; Moderator; Mini Symposium Faculty; Paper 95
Smith, Carla	*(2-AONA Faculty; 9-Orthopedic Overseas Board Member)*	Skills Lab Faculty
Smith, Jeffrey M	*(2,3B-Smith & Nephew; Stryker; 2-Synthes; 3B-Medtronic; 9-Orthopaedic Trauma Association (Public Relations Committee Chairman))*	Mini Symposium Moderator; Mini Symposium Faculty
Smith, R. Malcolm	*(2-Biomet; 3B-Globus; Synthes)*	Paper 83
Smith, Stephanie	*(n)*	Poster 67
Sobolev, Boris	*(n)*	Poster 40
Soles, Gillian	*(n)*	Paper 123; Poster 20

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Song, Hyung Keun	*(n)*	Paper 100
Sorkin, Anthony	*(2,3B,4-Stryker; 4-Johnson & Johnson)*	Poster 65
Speirs, Joshua	*(n)*	Poster 119
Spellman, Aimee	*(n)*	OTA Staff
Spence, David	*(n)*	Poster 76
Spiker, Andrea	*(n)*	Poster 57
Spraggs-Hughes, Amanda	*(n)*	Paper 84, 87, 90; Poster 13
Sprague, Sheila	*(3A-Global Resarch Solutions Inc.)*	FLOW Investigator
Staeheli, Gregory	*(n)*	Poster 25
Stannard, James P	*(3B-DePuy, A Johnson & Johnson Company; Ellipse Technologies, Inc.; Regeneration Technologies, Inc.; Smith & Nephew; 5-Arthrex, Inc; DePuy, A Johnson & Johnson Company; Synthes; 7-Thieme; 8-Journal of Knee Surgery; 9-AO Board of Trustees; AO Research Review Commission; Orthopaedic Trauma Association)*	BSFF Symposium Faculty
Starr, Adam J	*(1-Starrframe, LLC; 2-Smith & Nephew; 8-Journal of Orthopaedic Trauma)*	Symposium Faculty; Mini Symposium Faculty; METRC
Stauber, Martin	*(3A, 4,9-b cube AG)*	BSFF Paper 6
Steenburg, Scott	*(n)*	Paper 79; Poster 90
Steffes, Matthew	*(n)*	Poster 7
Steinlauf, Steven	*(1-Orbis Medical; Smith & Nephew; 2-DJ Orthopaedics; Smith & Nephew; 3B-DJ Orthopaedics; Orbis Medical; Smith & Nephew; 4-Smith & Nephew)*	Poster 12
Stephan, Horst	*(n)*	Paper 43

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DISCLOSURE LISTING – ALPHABETICAL

Sterling, Robert	*(8-Journal of Arthroplasty; Journal of Surgical Education; 9-AAOS; American Orthopaedic Association; Maryland Orthopaedic Association)*	Poster 57
Stern, Lorraine	*(n)*	Poster 20
Stewart, Andrew	*(n)*	BSFF Paper 14
Stewart, Samuel	*(n)*	Poster 22, 23
Stinner, MAJ Daniel	*(9-AAOS; Orthopaedic Trauma Association; Society of Military Orthopaedic Surgeons)*	Skills Lab Faculty; Paper 106; Poster 8; METRC
Stockton, David	*(n)*	Paper 95
Stollenwerck, Guido	*(n)*	Poster 37
Stone, Trevor	*(2-Bioventus Global; 6-Synthes; Stryker)*	Paper 33; FLOW Investigator
Stoops, T. Kyle	*(n)*	BSFF Paper 17
Strong, Benjamin	*(n)*	Paper 121
Stuart, Ami	*(3A-CoNextions Medical Inc.)*	Paper 93, 128
Summers, Hobie	*(3B-Olympus)*	Case Presentation Faculty; Paper 56; Poster 19
Summers, Spencer	*(n)*	Poster 12
Sun, Xin	*(n)*	FLOW Investigator
Sun, Xu	*(n)*	Paper 88
Sundem, Leigh	*(n)*	Paper 123
Swamy, Girish	*(n)*	Paper 101
Swe, Khine	*(n)*	Paper 108
Switzer, Julie	*(5-Stryker)*	Poster 114
Swords, Michael	*(2-Pacira; 3B-Depuy Synthes; 5-AO Foundation; 9-Membership Committee American Orthopedic Foot & Ankle Society)*	Poster 2
Tagge, Sean	*(n)*	BSFF Paper 16

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Taitsman, Lisa	*(8-Journal of Orthopaedic Trauma Geriatric Orthopaedic Surgery & Rehabilitation; 9-American Orthopaedic Association; Orthopaedic Trauma Association)*	Mini Symposium Faculty
Tanner, Stephanie	*(n)*	Poster 105; FLOW Investigator
Taormina, David	*(n)*	Poster 94
Tareen, Jarid	*(n)*	Paper 131
Tarkin, Ivan	*(2,5-Synthes; Zimmer; 5-Pittsburgh Foundation)*	Poster 102
Teasdall, Robert	*(n)*	Poster 105
Teague, David	*(8-Journal of Orthopaedic Trauma; 9-Center for Orthopaedic Trauma Advancement (COTA))*	Paper 73, 86; METRC
Tejwani, Nirmal C	*(2,3B-Zimmer; Stryker; 9-AAOS; Orthopaedic Trauma Association; Federation of Orthopaedic Trauma)*	OTA BOD; Case Presentation Faculty; Poster 4, 109
Templeman, David	*(1,3B-Zimmer; 3C-Orthofix, Inc.; 4-Naroflex; 9-AAOS; American Board of Orthopaedic Surgery, Inc.)*	Paper 73; Poster 78
Tennent, David	*(n)*	Paper 106; Poster 8
Teunis, Teun	*(n)*	Paper 83, 125
Thacher, Ryan	*(n)*	Paper 40, 49
Thakore, Rachel	*(n)*	Paper 102; Poster 70
Theologis, Alexander	*(n)*	Poster 123
Thompson, Jeremy	*(n)*	Poster 91
Thornton, Emily	*(n)*	Paper 83, 125
Tieszer, Christina	*(n)*	Paper 33
Toledano, CAPT James E	*(n)*	METRC
Tomasino, Allison	*(n)*	BSFF Paper 25

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DISCLOSURE LISTING – ALPHABETICAL

Tonnos, Frederick	*(n)*	Poster 85
Toogood, Paul	*(n)*	Poster 84
Torgerson, David	*(n)*	Paper 32
Tornetta, Paul III	*(1-Smith & Nephew; 7-Wolters Kluwer Health - Lippincott Williams & Wilkins; 8-Journal of Orthopaedic Trauma)*	Moderator; Case Presentation Moderator; Skills Lab Leader; Poster Tour Guide; BSFF Paper 12; Paper 35, 69, 73, 86, 98, 107; Poster 15, 78; FLOW Investigator; METRC
Trask, Kelly	*(n)*	Paper 33; Poster 15
Trenholm, Andrew	*(2-DePuy Synthes; 3C-Cartiva, Inc.; 6-Academic Fellowship Funding; 9-OTA Research Committee)*	Paper 33
Triantafillou, Kostas	*(n)*	Paper 38
Tsai, Stanley	*(3A-Legacy Research Institute)*	BSFF Paper 10
Tutton, Elizabeth	*(n)*	Paper 31
Tyldsley, Amanda	*(n)*	Poster 73
Umpierreze, Erica	*(n)*	Paper 114
Unno, Florence	*(n)*	Paper 42
Upasani, Vidyadhar	*(2,3B-OrthoPediatrics)*	Poster 74, 75
Vaidya, Rahul	*(1-Smith & Nephew; 1,2,5,6-Synthes; 2,3B,3C-Stryker; 8-European Spine Journal)*	Poster 85
Vallier, Heather A	*(8-Journal of Orthopaedics and Traumatology; 9-AAOS; Center for Orthopaedic Trauma Advancement; Orthopaedic Trauma Association)*	OTA BOD; Mini Symposium Moderator; Paper 39, 60, 69, 107, 119, 120; Poster 11, 89, 95, 97, 121, 124; METRC
Van de Meent, Henk	*(n)*	Poster 29
Van Der Meijden, Olivier	*(6-AO)*	Paper 118

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van Embden, Daphne	*(6-Medisch Centrum Haaglanden)*	Poster 37
Van Lieshout, Esther	*(n)*	Paper 129
Vanek, Kenneth	*(n)*	BSFF Paper 5
VanHouten, Jacob	*(n)*	Poster 17, 59
Varga, Endre	*(n)*	Paper 43
Varthi, Arya	*(n)*	Paper 78; Poster 66
Vasquez, Matt	*(n)*	Paper 111
Vauclair, Frédéric	*(n)*	Paper 126
Verhofstad, Michael	*(n)*	Paper 118, 129
Verleisdonk, Egbert	*(n)*	Paper 118
Virkus, Walter	*(2,3B-Smith & Nephew; 2,3B,4-Stryker; 3A-Novartis; 3B-Collplant; 4-Johnson & Johnson; 7-SLACK Incorporated; 8-American Journal of Orthopedics; Journal of Bone and Joint Surgery - American; Clinical Orthopaedics and Related Research; Journal of Orthopaedics and Traumatology)*	Poster 65
Viskontas, Darius	*(5-Stryker; Synthes)*	Paper 33
Vodovotz, Yoram	*(n)*	BSFF Symposium Faculty
Vollmer, Nina	*(n)*	BSFF Paper 9
Voloshin, Ilya	*(2-Arthrex; Zimmer; Acumed; Arthrosurface; 3B-Arthrex; Zimmer, Acumed; Arthrosurface; 5-Arthrex; Acumed; 9-Reasearch Committee; Education Committee for AANA; Membership Committee for ASES)*	Paper 121
von Rechenberg, Brigitte	*(n)*	BSFF Paper 6, 10
Vos, Lara	*(n)*	Poster 131
Vovos, Tyler	*(n)*	Paper 45

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Vrabec, Gregory	*(4-Smith & Nephew; Teva Pharm; Zimmer; 5-Synthes)*	BSFF Paper 13
Waddell, James	*(3B,6-Smith & Nephew; Stryker; 7-Saunders/Mosby-Elsevier; 9-Association for the Rational Treatment of Fractures)*	Paper 96
Wagner, Eric	*(n)*	Poster 45
Wagner, Scott	*(n)*	Poster 126
Walenkamp, Monique	*(n)*	Poster 131
Walker, Justin	*(n)*	Mini Symposium Faculty
Wallace, Anna	*(n)*	Paper 60
Walley, Kempland	*(n)*	Poster 44
Walmsley, David	*(n)*	Paper 96
Wang, Dong	*(n)*	Paper 95
Wang, Hu	*(n)*	Paper 66
Wang, Manyi	*(n)*	Paper 88
Wang, Stewart	*(n)*	Paper 76; Poster 36
Ward, Anthony	*(2-Stryker UK; 9-Regional Specialty Professional Advisor; Royal College of Surgeons England and British Orthopaedic Association)*	Poster 86
Ward, Catherine	*(n)*	BSFF Paper 20
Ward, Robert	*(n)*	Poster 106
Warner, Stephen	*(n)*	Paper 40, 46, 49, 89; Poster 48
Warner, William Jr	*(7-Elsievier; 9-Clinical Orthopedic Society)*	Poster 76
Waterman, Brian	*(7-Elsevier; 8-Arthroscopy; 9-Arthroscopy Association of North America; Society of Military Orthopaedic Surgeons)*	Poster 119

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Waters, Peter M	*(4-Celgene; Sangamo; 7,8-Wolters Kluwer Health - Lippincott Williams & Wilkins; Wolters Kluwer Health - Lippincott Williams & Wilkins; 9-American Society for Surgery of the Hand; Pediatric Orthopaedic Society of North America)*	Paper 53
Watson, J Tracy	*(1,2,3B-Biomet; Smith & Nephew; 3B-Bioventus; 3C-Acumed, LLC; 6-Smith & Nephew; 8-ortho knowlege online; 9-Orthopaedic Trauma Association; Orthopaedic Trauma Association)*	BSFF Moderator; BSFF Symposium Moderator; BSFF Symposium Faculty; Case Presentation Faculty; Poster Tour Guide; Paper 92; METRC
Watts, Chad	*(n)*	Poster 45
Weatherford, Brian	*(n)*	Poster 104
Weaver, Michael	*(n)*	Paper 110, Poster 21
Webb, Matthew	*(n)*	Paper 78, 103; Poster 56, 66, 98
Weber, Donald	*(5-Zimmer Canada)*	Paper 54; Poster 67
Wegener, Stephen	*(7-Rehabilitation Psychology-American Psychological Association)*	Symposium Faculty; Poster 72
Weinberg, Douglas	*(n)*	Paper 107; Poster 89
Weldy, Eric	*(n)*	Poster 76
Wenke, Joseph	*(6-Next Science, LLC; 8-Tissue Engineering, Journal of Surgical Orthopaedic Advances)*	BSFF Paper 20; Paper 106
Werner, Shawn	*(n)*	Poster 63
Westberg, Jerald	*(n)*	Paper 107
Westgeest, Joseph	*(n)*	Paper 54
Westphal, Ralf	*(n)*	BSFF Paper 27
Wetzel, Robert	*(n)*	Poster 65
Whale, Casey	*(n)*	BSFF Paper 16; Paper 99; Poster 18

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White-Dzuro, Gabrielle	*(n)*	Poster 53, 59
White, Raymond R	*(1-Zimmer; 3B-Zimmer)*	Moderator
White, Timothy	*(3B,5,6-Acumed, LLC; 3C-Smith & Nephew)*	BSFF Symposium Faculty; Paper 30
Whiting, Jeffrey	*(n)*	BSFF Paper 11
Whiting, Paul	*(n)*	Paper 38, 70; Poster 5, 53, 59
Widuchowski, Jerzy	*(n)*	Paper 43
Wijdicks, Frans-Jasper	*(n)*	Paper 118
Wikerøy, Anette	*(9-Norwegian Orthopaedic Association)*	Paper 68
Wilken, Jason	*(n)*	Poster 8
Willett, Keith	*(1-Zimmer)*	Paper 31
Willett, Thomas	*(n)*	BSFF Paper 18
Willey, Michael	*(n)*	Poster 39
Williams, Anthony	*(n)*	Mini Symposium Faculty
Williams, J	*(n)*	Paper 128
Williams, Joan	*(n)*	Poster 9
Williams, Seth	*(3B-Depuy; Synthes; Spine)*	Poster 96
Wilson, Frederic B	*(9-AAOS; SIGN)*	Skills Lab Faculty
Wimberly, R Lane	*(n)*	Case Presentation Faculty; Paper 51
Winkelmann, Marcel	*(n)*	BSFF Paper 1
Wiznia, Daniel	*(n)*	Poster 38
Wolinsky, Philip R	*(2,3B-Zimmer; 5-Synthes; 8-Journal of Orthopedic Trauma; 9-OTA, AAOS, AOA, ACS)*	Case Presentation Faculty; Poster 64
Woodside, Mitchell	*(n)*	BSFF Paper 18
Wooldridge, Adam	*(n)*	Poster 31
Worden, Andrew	*(n)*	Poster 7
Working, Zachary	*(n)*	Paper 93, 128; Poster 33, 133
Wright, Craig	*(n)*	BSFF Paper 21

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Wu, Xinbao	*(n)*	Paper 88
Wu, Yongren	*(n)*	BSFF Paper 5
Wuertzer, Scott	*(n)*	Poster 77
Wyatt, Marilynn	*(n)*	Paper 80
Wyrick, John	*(3B-Stryker)*	Poster 111
Yamashita, Haruyosi	*(6-Niigata University*	Paper 37
Yang, Kyu Hyun	*(1-Zimmer)*	Paper 100
Yao, Hai	*(n)*	BSFF Paper 5
Yasuda, Tomohiro	*(n)*	Paper 37
Yaszay, Burt	*(1-Orthopediatrics; K2M; 2-DePuy; K2M; Stryker; 3B-DePuy; Globus Medical; K2M; Nuvasive; 5-DePuy; Harms Study Group; 8-Spine Deformity; 9-AAOS; POSNA; Scoliosis Research Society)*	Poster 74, 75
Yoeli, Gideon	*(n)*	Poster 61, 62
Yoon, Patrick	*(3B- Orthofix, Inc; Arthrex, Inc; 8- Foot and Ankle International; Journal of the American Academy of Orthopaedic Surgeons; 9-AAOS; American Orthopaedic Foot and Ankle Society; Orthopaedic Trauma Association; Surgical Implant Generation Network)*	Skills Lab Faculty
Yoon, Richard	*(n)*	Paper 75; Poster 32, 34
Yu, Stephen	*(n)*	Poster 7
Zagh, Istvan	*(n)*	Paper 43
Zaman, Saif	*(n)*	Paper 77
Zamora, Rodolfo	*(n)*	BSFF Paper 21
Zeckey, Christian	*(n)*	BSFF Paper 1
Zeng, Bingfang	*(n)*	Paper 95
Zerhusen, Timothy	*(n)*	Paper 55, 104, 116

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DISCLOSURE LISTING – ALPHABETICAL

Zhang, Chong	*(n)*	Paper 99, Poster 18
Zhang, Kun	*(n)*	Paper 66
Zhang, Yu Ling	*(n)*	Paper 29
Zheng, Xuanlin	*(n)*	Paper 100
Zhuang, Yan	*(n)*	Paper 66
Zirgibel, Brian	*(n)*	Paper 130
Zirkle, Lewis G Jr	*(3C-SIGN; 8-Orthoprenour; 9-Orthopaedic Trauma Association-international committee)*	Skills Lab Leader
Zomar, Mauri	*(n)*	Paper 33
Zych, Gregory A	*(9-OTA)*	METRC

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(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. *= Not available at time of printing. Refer to pages 545 - 547.

Cytokines as Predictors of Multiple Organ Dysfunction Syndrome of Polytrauma Patients: Osteoprotegerin and Lipocalin-2 Better than Interleukin-6?

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Background/Purpose: Multiple organ dysfunction syndrome (MODS) is with its unchanged high mortality is still one of the most severe complications in the posttraumatic course of severely injured patients. Thus an early detection of patients with an increased risk of developing MODS is crucial to help avoiding lethal courses. Interleukin (IL)-6 is, in this context, corresponding to its central role in regulation of posttraumatic inflammation, one of the gold-standard parameters for estimating individual risk profile. The paracrine osteoprotegerin (OPG) is part of the tumor necrosis factor superfamily and mediates various biologic effects including increased cytokine and chemokine synthesis. Lipocalin-2 (LCN) as an acute phase protein is among other things also of regulative importance within posttraumatic immune response. The primary end point of this study is the analysis of prognostic value of OPG and LCN for developing of posttraumatic MODS compared to IL-6.

Methods: A standardized arterial blood sample for plasma cytokine measurement was gathered from polytrauma patients (ISS = 16) between 16 and 65 years at days 1, 2, 3, 5, 7, and 14. A 10-mL probe was immediately centrifuged with 500g for 10 minutes. The plasma was extracted and preserved at -80°C. Cytokine analysis (IL-6, OPG) was made with flow cytometry/FACS, measurement of LCN/NGAL with ELISA (enzyme-linked immunosorbent assay). Clinical parameters were collected parallel. Diagnosis of MODS depended on the Marshall score. Statistical analysis included chi-squared test as well as Mann Whitney U test for nonparametric data with significance set at a P value < 0.05. Evaluation of the diagnostic value of IL-6, LCN, and OPG as MODS predictors was performed with ROC (receiver operating characteristic curve) analysis and the AUC (area under the curve). Cutoff points were defined on the basis of Youden's index.

Results: Altogether 234 samples from 39 patients (32 male, 7 female) with a mean age if 41.4 ± 20.4 years and a mean ISS of 34 ± 11 were analyzed. 7 patients (18 percent) died in the course of the treatment, 14 (36%) developed MODS. IL-6 as well as OPG and LCN were significantly increased within the MODS group (P < 0.001). According to ROC analysis, OPG and LCN were better predictors for MODS compared to IL-6. In addition, OPG distinguished best especially in the early phase.

Conclusion: OPG as well as LCN had a higher predictive value for developing MODS compared to IL-6 and were already significantly increased in the early phase. Thus, measuring OPG and LCN could help to identify patients with imminent multiple organ dysfunction syndrome earlier and hence contribute to further decrease mortality of polytrauma.

A Severe Hemorrhagic Shock Leads to Delayed Fracture Healing and Biomechanical Instability in a Murine Model

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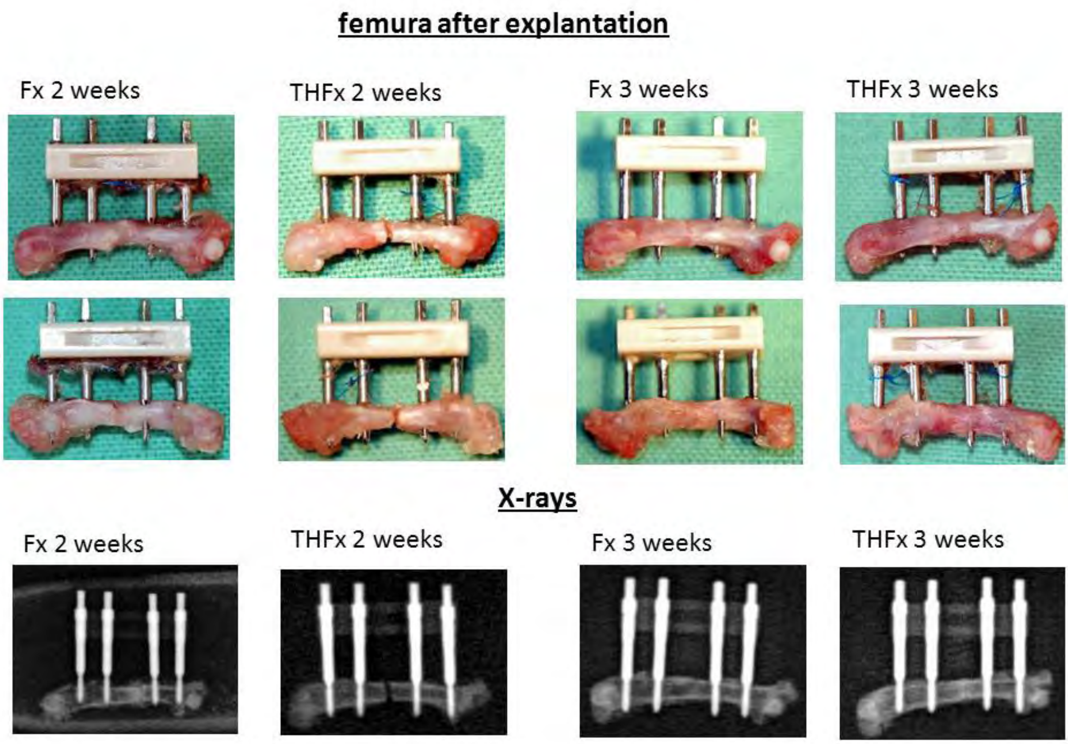
Purpose: In patients with multiple trauma, a delayed fracture healing is often diagnosed, whereas the pathomechanisms are not well known today. The purpose of the study is to evaluate the effect of a severe hemorrhagic shock on fracture healing in a murine model.

Methods: 10 male C57BL/6N mice per group (Fx, THFx, Sham) and time point were used in this experiment. The Fx group received an osteotomy after an external fixator was fixed to the right femur. The THFx group additionally received a pressure-controlled hemorrhagic shock (TH) with a mean arterial blood pressure of 35 mm Hg over a period of 90 minutes. Afterwards, resuscitation with 4 times the shed blood volume of Ringer solution was performed. Animals of the Sham group received both the implantation of a catheter and an extermal fixator but neither a blood loss nor an osteotomy was performed. After 1, 2, 3, 4, or 6 weeks, the animals were sacrificed. Afterwards the bones were radiographed, analyzed by micro computed tomography (μCT) and underwent a 3-point bending test. Statistical analysis was performed using SPSS 22 (IBM). Statistical significance was set at P < 0.05. Comparisons between groups were performed using the Mann–Whitney U test.



See pages 47 - 108 for financial disclosure information.

Results: One week after surgery the bones of the Fx and the THFx mice were macroscopically instable. After 2 weeks, the Fx group showed a stable bridging of the fracture analyzed by radiograph and μCT, whereas the bones of the THFx group were instable in 50% of the cases (see figure). Interestingly, the 2-week THFx mice showed a stable bridging with a blood loss under 30% of the whole blood volume. In contrast, animals with a blood loss higher than 30% of the whole blood volume showed an unstable fracture. 3 weeks after surgery, the bones of both groups were bridged. First results of the 3-point bending tests showed a reduced tensile strength of the THFx group after 2 and 3 weeks in comparison to the Fx group.

Conclusion: A hemorrhagic shock has a negative effect on fracture healing. In this context, the amount of the removed blood in terms of a "30% threshold" plays a decisive role.

PAPER ABSTRACTS

Vancomycin and Imipenem Release from Nails Covered with Antibiotic-Loaded Acrylic Cement: A Pharmacokinetic Study

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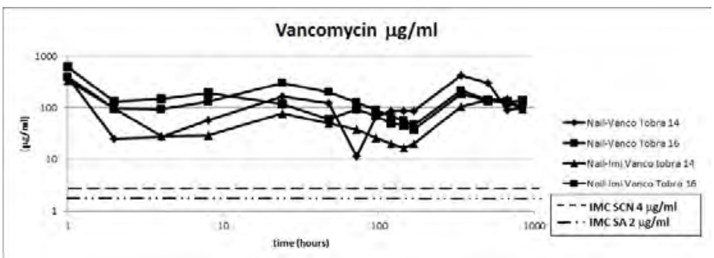
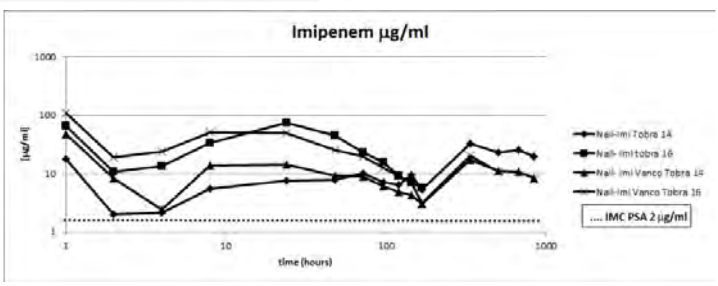
Purpose: There is a lack of information in the literature regarding pharmacokinetic properties of nails covered with antibiotic-loaded acrylic cement (ALAC). The aim of this research work was to describe the release of vancomycin and imipenem from nails covered with ALAC over a period of 6 weeks. Furthermore, we analyzed if an increase in the diameter of the nail resulted in an increase in the amount of cement applied, or if the combination of the two antibiotics in the same cement affects the amount of antibiotics released.

Methods: Two groups of three nails each were defined. Group 1 consisted of three 10-mm nails covered with cement with a final diameter of 14 mm: Nail 1, Simplex cement with tobramycin + 4 g of vancomycin per 40 g of cement; Nail 2, Simplex cement with tobramycin + 2 g of imipenem per 40 g of cement; and Nail 3, Simplex cement with tobramycin + 4 g of vancomycin + 2 g of imipenem per 40 g of cement. In Group 2 we used the same antibiotics but the three 10-mm nails were covered with cement with a final external diameter of 16 mm.

Results: In vitro concentrations of vancomycin and imipenem maintained above the MIC (minimum inhibitory concentration) for at least 6 weeks. Increasing the external diameter of the nail did not modify the concentration of antibiotics released significantly (P = 0.481). The release of the antibiotics was not significantly modified by the combination of vancomycin and imipenem in the same nail (P = 0.38).

Conclusion: it is possible to achieve in vitro concentrations of vancomycin and imipenem above the MIC for at least 6 weeks with nails covered with antibiotic-loaded acrylic cement Neither the combination of both antibiotics nor the increase in the diameter of the nail significantly modified the release of the antibiotics.





See pages 47 - 108 for financial disclosure information.

Elution Characteristics of PMMA Bone Cement Intramedullary Spacers Impregnated with Vancomycin and Tobramycin

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Purpose: Septic nonunion following intramedullary (IM) stabilization of tibial shaft fractures is typically treated with removal of the IM nail (IMN) followed by either IM antibiotic-impregnated polymethylmethacrylate (PMMA) bone cement beads with external fixation stabilization or, more recently, various antibiotic cement-coated IM nailing techniques. As PMMA beads are classically left for 6 to 8 weeks to treat various orthopaedic infections, it became the consensus among orthopaedists that PMMA IMNs also remain 6 to 8 weeks, as reflected in the literature. Although elution kinematic studies have been described for cement beads and small block spacers, no study, to our knowledge, has evaluated the elution properties of long cylindrical IM cement spacers.

Methods: Two antibiotic-impregnated bone cement groups were prepared. Group 1 (Beads) contained 1.0 g of powdered vancomycin and 1.2 g of powdered tobramycin mixed in 40 g of bone cement and rolled into small spheres before placing inside a 40-French fenestrated chest tube. Group 2 (Nails) consisted of 2.0 g of powdered vancomycin, 2.4 g of tobramycin, and 80 g of bone cement, which was fashioned into an IMN using a 40-French chest tube. Ten samples were made for each group. The samples were then placed in PVC piping with 220 mL of normal saline and watertight seal was ensured. Groups were placed in an oscillating shake water bath at 37°C with 1.0 mL testing samples taken from the enclosed PVC piping every 24 hours with replacement of the 220 mL normal saline solution. At day 7, the testing interval was extended to every 7 days for a total of 6 weeks of testing. Concentrations of vancomycin and tobramycin in the testing samples were then determined and compared between the two groups using t tests and Fisher exact tests.

Results: Group 1 (Beads) showed high rates of elution early with logarithmic release of vancomycin; however, by the 6th day of testing the concentration dropped below the detection threshold of 5 μg/mL. Group 2 (Nails) showed early elution of vancomycin less than one-third that of Group 1 Beads, and by the 3rd day of testing the concentration fell below 5 μg/mL. Although brief, this difference was significant ($P < 0.004$). The elution rates of tobramycin showed high rates of antibiotic release with exponential decay as seen with vancomycin. At each time point, beads showed higher elution rates than nails with statistical significance shown up to week 4 of testing. The mean total of tobramycin released in Group 1 was 296.0 μg and 81.9 μg in Group 2.

Conclusion: With the drawbacks of external fixation, more surgeons are looking for treatment options to avoid its application. Various PMMA IMN constructs have been described to provide stability of the fracture but at the expense of antibiotic delivery. In this evaluation of elution rates of PMMA antibiotic-impregnated beads and long cylindrical IM nails, the antibiotic beads proved statistically superior.

PAPER ABSTRACTS

Effect of External Beam Irradiation on the Pathway of Bone Fracture Healing

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Background/Purpose: External beam irradiation of malignant lesions metastatic to bone has become a widely accepted therapy to prevent fracture and promote bony healing of lesions that compromise the structural integrity of the skeleton. Likewise, following operative treatment of pathologic fractures, external beam irradiation is utilized to accomplish local tumor kill necessary for disease control but potentially interferes with the concurrent need to support fracture healing. We hypothesize that fracture healing by endochondral ossification will be preferentially more impaired than healing by intramembranous ossification in irradiated animals due to radiation-mediated inhibition of the neovascularization and mineralization of cartilage callus during its transition to bone. Therefore, the objective of this study is to investigate the differential effects of radiation on the two pathways of bone healing and propose an optimal method of surgical fracture repair for managing malignant fractures that require external beam irradiation for local tumor control.

Methods: Sprague-Dawley (SD) rats (n = 24; male) were used to develop a bilateral iatrogenic femur fracture model for concurrent study of both healing pathways of bone in the same animal. One side was repaired with a novel, customized dynamically locked intramedullary nail (healing via endochondral ossification) while the other side was rigidly fixed with plate and screws (healing via intramembranous ossification) (Figure 1). On postoperative day 3, the rats in the radiation group (n = 12) underwent radiation treatment using a customized ¼-in-thick lead shield with a small aperture to restrict x-ray exposure to only the fracture sites. The PANTAX x-ray unit was operated at 250 kVp, 13 mA with 1.0-mm aluminum plus 0.5-mm copper added filtration (half value layer 1.56 mm copper) to deliver a single dose of 8 Gy to each femur. In order to study the progression of callus formation, the rats in both control and radiation groups were euthanized at various time points (weeks 1, 2, and 4). The morphology and microstructure of ossification at the fracture site was quantitatively assessed using a Scanco μCT40 system (70 kVp, 114mA and 10 μm isotropic voxel size). Callus volume (CV), bone volume (BV), callus volume fraction (CV/BV), and tissue mineral density (TMD) were determined with a 3-dimensional (3D) volumetric reconstruction technique. A Student t test was used for statistical analysis between control and radiation animals.

Results: A thin layer of calcified callus (Figure 2a, shown in transparent area) gradually formed from week 1 to week 4 around the fracture site in femurs repaired by plate fixation. In the plated femurs, there was no significant difference in the bone volume fraction (CV/BV) of the control group versus radiation group at any of the

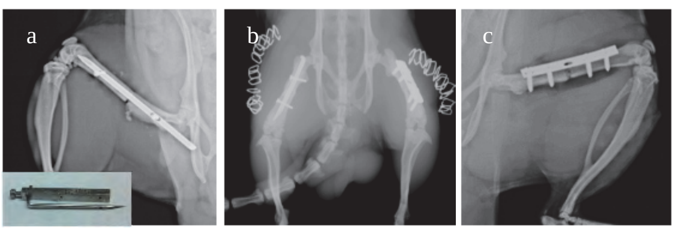
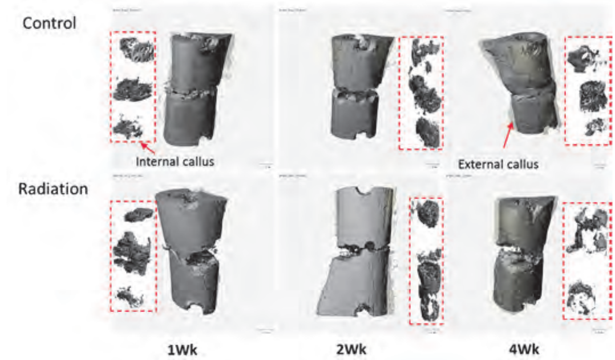


Figure 1. a) Lateral X-ray of IM nail (right femur). b) Anterior-Posterior xray of both femurs. c) Lateral X-ray of plate (left femur).

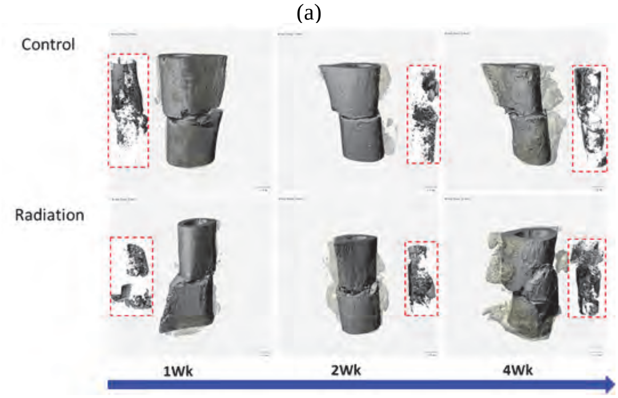
See pages 47 - 108 for financial disclosure information.

studied time points (Figure 3a). The volumes of calcified callus in the control and radiation groups at week 4 were 22.12 ± 7.49 mm3 and 19.73 ± 5.57 mm3, respectively. By contrast, in femurs repaired by intramedullary (IM) nail fixation, a thicker layer of calcified callus formed around the fracture site (Figure 2b). In the IM nail cohort, a significant difference in the bone volume fraction (CV/BV) was observed between control (39.76 ± 3.50 mm3) and radiation (28.04 ± 7.50 mm3; P <0.005) groups at week 4 (Figure 3b), representing an approximately 40% decrease in bone volume fraction in the radiation group. No statistically significant differences were observed at weeks 1 and 2.

Conclusion: This study suggests a differential effect of radiation on the two pathways of bone healing--an insignificant effect on primary bone healing, or intramembranous ossification, as promoted plate fixation, compared with a significant inhibition of endochondral ossification, or secondary bone healing, as occurs with IM nail fixation. A potential explanation for this may be radiation-mediated inhibition of neovascularization and mineralization of cartilage callus during its transition to bone in the endochondral ossification pathway. In conclusion, internal fixation of malignant metastatic fractures with compression plating, rather than intramedullary devices, may be a more appropriate and durable option for fracture repair of pathologic fractures that require external beam irradiation for local tumor control.

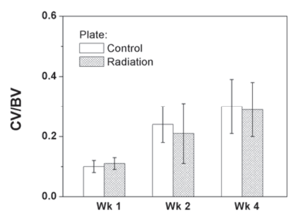


(a)

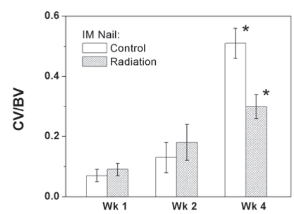


(b)

Figure 2. Typical 3D µCT images of external and internal callus formed around the bone fracture site in (a) rat femurs using plate fixation and (b) rat femurs using IM nail fixation at week 1, week 2 and week 4.



(a)



(b)

Figure 3. Effects of radiation on the pathways of bone fracture healing in (a) rat femurs using plate fixation and (b) rat femurs using IM nail fixation at various time periods. (*p<0.005, n=6/group at week 4)

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.

Novel PTH-Based Bone-Graft Substitute for Treatment of Fractures: Results From a Large Ovine Tibial Plateau Defects Study

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Background/Purpose: A novel formulation containing a modified, covalently linkable parathyroid hormone (TGplPTH1-34) in fibrin with hydroxapatite/tricalcium phosphate (HA/TCP) granules has been developed for use as a bone-graft substitute. The formulation has been optimized such that the TGplPTH1-34 is covalently linked to the fibrin matrix during polymerization so that the product is able to provide bioactivity (through the linked TG-plPTH1-34) as well as compression resistance (from the presence of fibrin-granule mixture). The product is therefore a bone-graft substitute, to be used for treating bony defects that are exposed to mechanical stresses. One prime indication has been tibial plateau fractures (TPFs), and in order to determine whether this material is appropriate for clinical use in this space, it was first tested in an ovine metaphyseal model for TPF.

Methods: Following creation of a 3.5-cm3 cuboidal defect in the cancellous bone of the proximal tibia directly below the articular surface, sheep were treated with either TGplPTH1-34 (at 0.4 mg/mL or 1.0 mg/mL) in fibrin with HA/TCP or cancellous autograft. Animals were followed up at 6 and 12 months. Primary healing measures were bone formation, as determined by micro computed tomography (CT) as well as the mechanical integrity of the newly formed tissue, measured through both nondestructive mechanical tests on the whole bone as well as destructive tests on bone cores. Safety parameters were measured including systemic PTH, PTH-specific antibodies, and serum calcium.

Results: 18 sheep were treated in the study, and all animals tolerated the material well. Micro CT measurements of the bone formation demonstrated that all three treatments were efficacious, with the autograft (40.0%) and high concentration (41.7%) creating more bone than the lower concentration (24.6%) at 6 months. This trend was also observed in the biomechanical testing. Defects treated with the 1.0-mg/mL TGplPTH1-34 in fibrin with granules had a stiffness (1502 N/mm2) that was higher than that for both autograft treated bone (1394 N/mm2) as well as noninjured, contralateral bone (1103 N/mm2). This was mirrored in the ultimate strength, where the bone following treatment with the 1 mg/mL product could bear a higher load before failure (18.7 N/mm2) than the autograft treated bone (14.7 N/mm2) and the noninjured bone (18.7 N/mm2). The data at 12 months confirmed the early stage findings.

Conclusion: Here, the efficacy of a novel bone-graft substitute based on the local retention of TGplPTH1-34 in a fibrin matrix has been shown. In a large, ovine metaphyseal defect model, healing of the bony defect was demonstrated both radiologically (with micro CT) as well as functionally (biomechanical testing). In fact, at the 6-month time point, the newly formed bone following treatment with the material was at least as strong if not stronger than both

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defects treated with autograft and even uninjured, contralateral bone. The combination of this data demonstrates that this novel bone-graft substitute is a potent, efficacious tool for treating large defects.

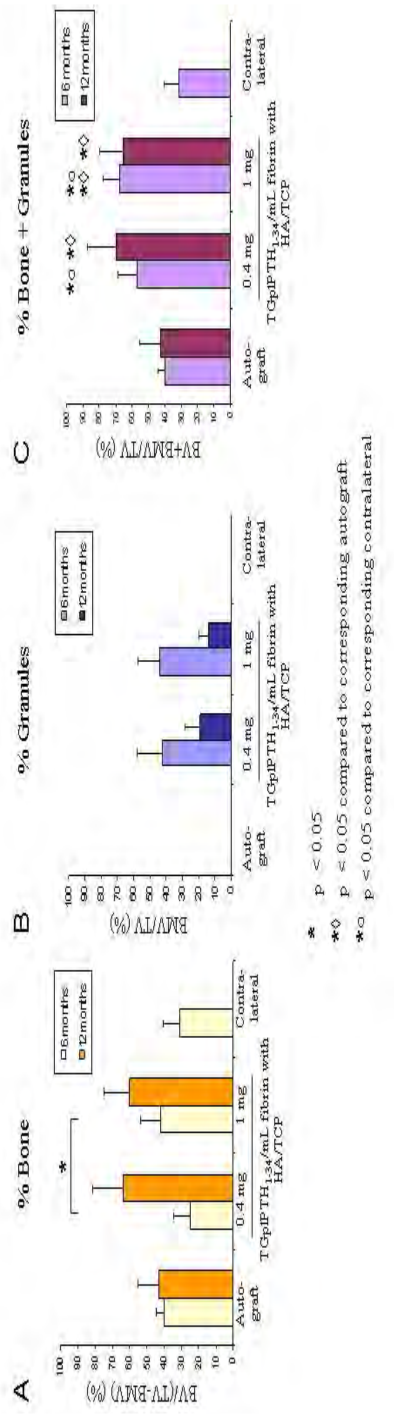

Figure: mCT analysis at 6 and 12 months of bone formation and HA/TCP granule content in the defect for the autograft group, the 0.4 mg modified TGplPTH$_{1-34}$/mL fibrin with HA/TCP granules group, the 1 mg TGplPTH$_{1-34}$/mL fibrin with HA/TCP granules group and a similar bone portion from the contralateral bone. A: Percentage of the bone volume (BV) in the available space (total volume minus the granule volume, %BV/(TV-BM). B: percentage of HA/TCP granules (BM) in the total volume (TV). C: percentage of bone (BV) plus HA/TCP granules (BM) in the total volume (TV). * $p<0.05$ statistically significant. *◊ $p<0.05$ statistically significant compared to the corresponding autograft group, *○ $p<0.05$ statistically significant compared to the corresponding contralateral group.

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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.

Pharmaceutical and Genetic Depletion of Sclerostin and the Effect on Fracture Healing

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Purpose: Sclerostin is a secreted glycoprotein that interacts with LRP5 (low density lipoprotein receptor-related protein 5) receptor on osteoblasts and inhibits the intracellular Wnt signaling pathway, leading to decreased bone formation. When sclerostin is inactivated, bone formation is therefore stimulated. This stimulation has been proven in fracture studies, which showed that sclerostin-deficient mice have larger and stronger calluses with accelerated fracture healing, both in sclerostin knockout and sclerostin antibody injection models. These observations suggest that sclerostin inhibition and depletion show improved and accelerated fracture healing, but the effect of these two mechanisms have not been compared to asses the accurate effect of the Scl-Ab (sclerostin-neutralizing monoclonal antibody) injections. Therefore we designed a study to compare the effect of sclerostin depletion (sclerostin knockout) and inhibition (Scl-Ab injection).

Methods: 10-week-old male SOST (sclerostin) knockout (KO) (N = 20) and Wild-type (WT) (N = 40) mice underwent insertion of a tibial intramedullary pin after which a midshaft tibial osteotomy was performed. The mice were divided into three groups: SOST KO (N = 20), WT with Scl-Ab injection (N = 20) and WT with saline injection (N = 20). The Scl-Ab group received an intravenous dose of 100 mg/kg weekly starting on day 7. Each group was managed and sacrificed according to the specified protocol (Fig. 1). For data analysis, one-way ANOVA (analysis of variance) was performed followed by Tukey's post hoc test at each time point. P values <0.05 were considered statistically significant.

Results: Both Scl-Ab and KO groups showed significantly increased trabecular BV/TV (bone volume/total volume) at the fracture site (midshaft of the tibia) compared to the saline group at all time points and also showed no significant difference between them at all time points (except at 28 days postoperative) (Fig. 2). On biomechanical testing, the Scl-Ab and KO groups showed significant increased strength in stiffness at days 14, 28, and 35 compared to the saline group (Fig. 3A). Concerning ultimate force and work to failure the KO group showed significant increase in the force required compared to both the Scl-Ab and saline groups at 21, 28, and 35 days. While the Scl-Ab group showed increased force required to fracture the callus compared to the saline group at these time points, this was only significant for work to failure at 28 days (Figs. 3B and D).

Conclusion: Scl-Ab injections showed promising results, which were comparable to the complete depletion of sclerostin, especially at earlier stages of the healing process. In addition, our results indicate that sclerostin antibody exerts its greatest effect in the earlier stages of fracture healing (days 14 and 21), after which the healing process plateaus and thus completing this process at an earlier time point. Further research into accurate dosage and adequate timing of administration is required before these promising results can be implicated as a modality for accelerating fracture healing in humans and management of delayed union/nonunion.

See pages 47 - 108 for financial disclosure information.

Groups	KO	Scl-Ab	Saline	KO	Scl-Ab	Saline	KO	Scl-Ab	Saline	KO	Scl-Ab	Saline
µCT	N=5	N=5	N=5	N=5	N=5	N=5	N=5	N=5	N=5	N=5	N=5	N=5
BT	N=5	N=5	N=5	N=5	N=5	N=5	N=5	N=5	N=5	N=5	N=5	N=5

Figure 1: Fracture model protocol.

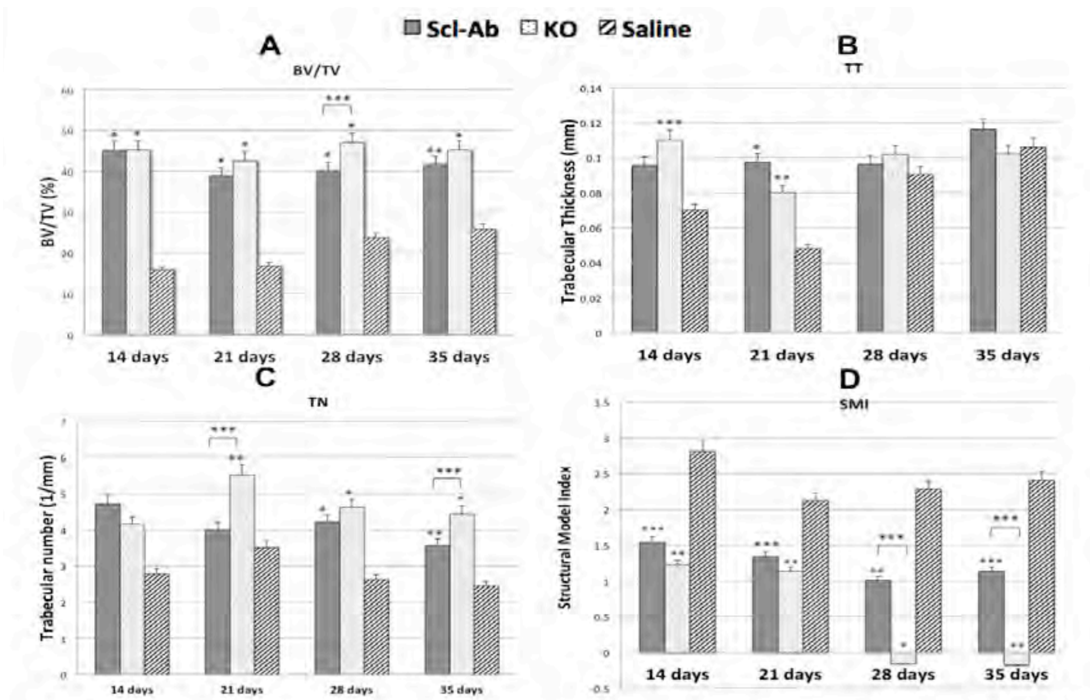

Figure 2: MicroCT results across all time points. Data presented as mean and standard error of the mean (*P<0.001, **P<0.01, ***p<0.05). **Abrev:** BV/TV; bone volume/total volume, Tb.Th; trabecular thickness, Tb.N; trabecular number, SMI; structural model index).

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.

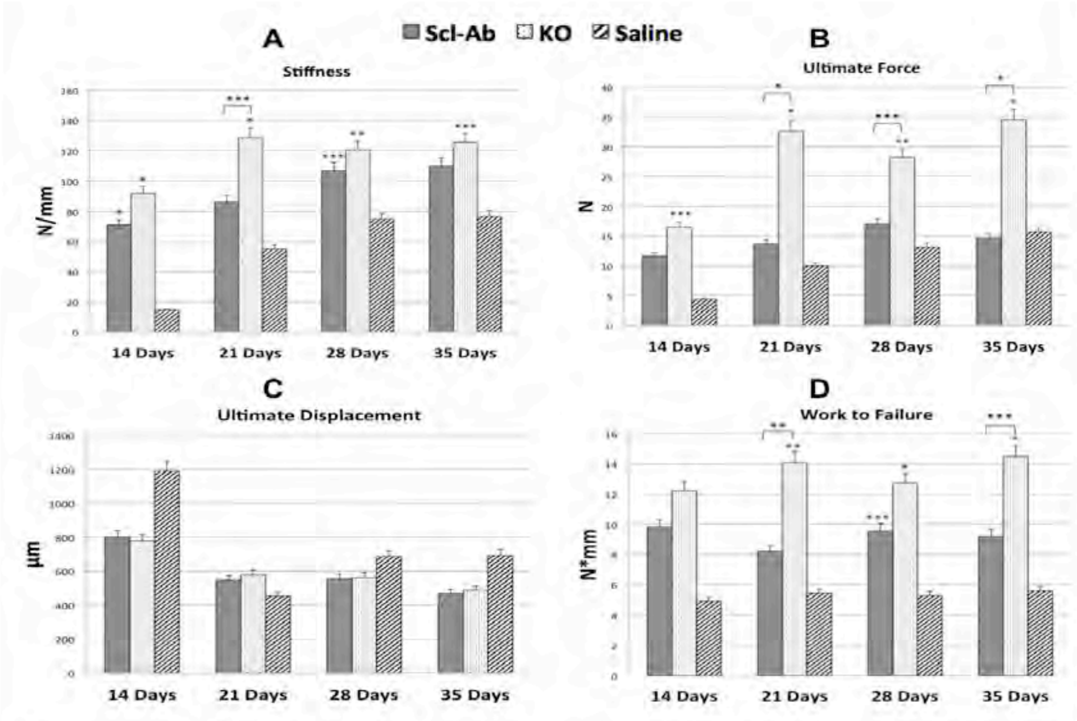

Figure 3: Biomechanical testing results across all time points. Data presented as mean and standard error of the mean (*P<0.001, **P<0.01, ***p<0.05).
Abrev: N; newton

Comparative Analysis of Thrombopoietin (TPO), a Novel Agent to Heal Segmental Bone Defects, with Bone Morphogenetic Protein-2 (BMP-2): A Hypothesis-Generating Transcriptomic Study

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Paul Childress, PhD[2]; *Todd McKinley, MD*[3]; *Benjamin Corona, PhD*[4];
Tien-Min Chu, DDS, PhD[5]; *Melissa Kacena, PhD*[2];
[1]*US Army CEHR, Fort Detrick, Maryland, USA;*
[2]*Indiana University; School of Medicine, Indianapolis, Indiana, USA;*
[3]*IU Health Physicians, Indianapolis, Indiana, USA;*
[4]*US Army Institute of Surgical Research, San Antonio, Texas, USA;*
[5]*Indiana University School of Dentistry, Indianapolis, Indiana, USA*

Background/Purpose: Segmental bone defects (SBDs), typically resulting from high-energy open fractures or infections, frequently have poor regional soft tissue and vascularity. Successful treatment typically requires composite interventions that restore soft tissue, reconstitute regional vascularity, and augment SBDs with autograft or synthetic agents. BMP-2, a mesenchymal cell stimulant, has emerged as the primary synthetic compound for SBD healing. We have developed an alternative compound, TPO, to heal SBDs. In contrast to BMP-2-mediated mesenchymal stimulation, TPO stimulates hematopoietic stem cells. Our preliminary studies have shown that TPO-mediated hematopoietic stimulation effectively heals bone, but also stimulates muscle healing and angiogenesis. Furthermore, phenotypic features of SBD healing stimulated by TPO demonstrate robust thickened cortical mature bone in the defect (Figure 1a), in contrast to secondary woven bone typically seen with BMP-2. These observations indicate that TPO-stimulated angiogenesis plays a central role in its bone formation. Collectively, TPO's expanded therapeutic footprint makes it an ideal agent for SBDs with compromised vascularity. The purpose of this study was to compare basic biologic signaling effects of TPO and BMP-2 on marrow cells using a computational biologic approach. We hypothesized that TPO and BMP-2 augmented transcriptomes would demonstrate fundamentally different signatures. We anticipated that both TPO and BMP-2 would augment networks of transcripts directly involved in bone healing, but increased concentrations of transcripts that code for muscle healing and angiogenesis would be measured in TPO-stimulated cells.

Methods: Femoral bone marrow cells were collected from 12 C57/BL6j mice and cultured in presence of BMP-2 (200 ng/mL), TPO (10 ng/mL), or saline as a negative control for 3 days (n = 4/group). Post treatment, cells were retrieved in Trizol, and mRNA was extracted and converted to cDNA. Gene expression analysis was done with high throughput dual-dye cDNA microarrays (Agilent). Pairwise t test with $P < 0.005$ found 756, 1033, and 2488 transcripts differentially expressed between the BMP-2 vs. saline, TPO vs. saline, and BMP-2 vs. TPO treatment groups, respectively. The genes were functionally annotated using a host of Systems Biology tools, including Ingenuity Pathway Analysis (IPA) and DAVID. Expression levels of select genes relevant to this study were validated using quantitative PCR (polymerase chain reaction) method.

Results: Principal component analyses revealed that 98% of variation between TPO and BMP-2 were accounted for within the first two principal components, confirming that treat-

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ment differences were captured by our analyses. TPO-stimulated cells showed an expanded signature of transcripts for a variety of growth factors that augment muscle healing, angiogenesis, and wound healing compared to BMP-2 treated cells (Figure 1b). In addition, TPO preferentially augmented transcription for networks of proteins located in the cell membrane. TPO-stimulated cells had particularly enriched genomic clusters that code for tubulin and actin, both cytoskeleton constituents, and plasma-membrane bound integrins suggesting that TPO plays an undiscovered role in orchestrating cellular mechanotransduction through the cell membrane into the cytoplasm.

Conclusion: TPO is a novel bone-healing agent with ubiquitous healing effects. Our initial studies have shown that TPO is effective in healing SBDs, and subsequently we have demonstrated that TPO also has potent effects on muscle healing and angiogenesis. The results from this study indicate that TPO may be an ideal agent to treat SBDs with poor adjacent soft tissue and compromised vascularity. Physiologically, TPO primarily stimulates hematopoietic tissue, which is responsible for initiating and orchestrating wound-healing in all injured tissues. Our study demonstrated that stem cells stimulated by TPO produced an expanded signature of growth factors and healing factors. These results, in concert with our foundational experiments, support trials to explore TPO efficacy in healing SBDs with poor soft tissue and compromised vascularity (ie, infection, open fractures).

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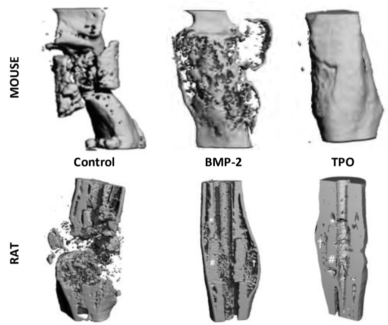
Figure 1a



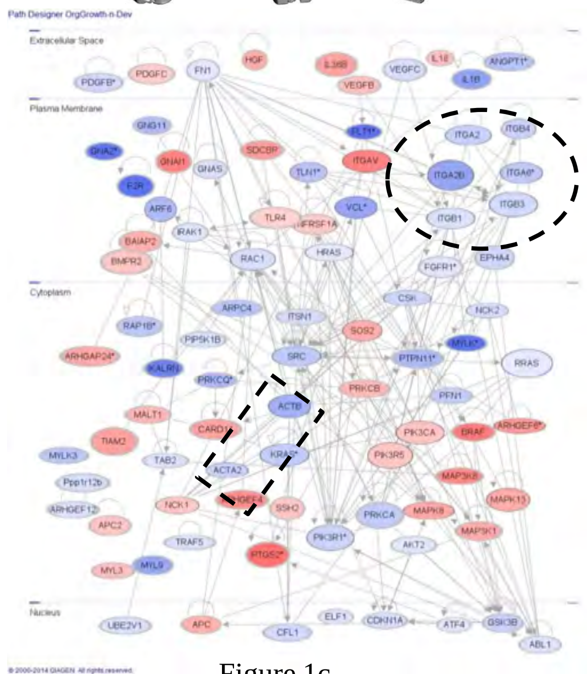


Figure 1c

Figure 1b

Biologic Function	Transcripts Upregulated by BMP	Transcripts Upregulated by TPO
Cytokines	- IL-4, IL-10, IL-22 signaling pathways; TGF-beta (primarily anti-inflammatory)	- IL-1, IL-3, IL-8, IL-16 and IL-17 signaling pathways (primarily pro-inflammatory)
Immune Response	- PKC8 signaling in T lymphocytes - CD28 signaling in T helper cells (mainly Bcell and Tcell receptor signaling)	- Leukocyte extravagation - Granulocyte adhesion (inflammatory cell peripheral adhesion)
Growth Factors	- EGF; ErbB; TGF-beta	- VEGF ; IGF-1; FGF; GM-CSF - Angiopoietin; Erythropoietin; (highly angiogenic and wound healing)
Cell Growth and Development	- Wnt/beta-catenin signaling - Mouse embryonic stem cell pluripotency	- Integrin signaling - Gap junction signaling - Epithelial adhesion junction
Skeleton and Muscle Development and Function	- Osteoblast differentiation (bone formation)	- Bone morphology - Muscle formation (balanced muscle and bone formation)

Figure 1 a – c: Rat and mouse SBDs treated with TPO invariably showed thickened mature cortices compared to abundant woven bone in BMP-2 treated specimens (Figure 1a) TPO stimulated cells demonstrated an expanded envelope of growth factors that affected angiogenesis and wound healing (Figure 1b red dashed circle). Fundamental differences in inflammatory cytokines and immune response were also detected. Representative pathway map (Figure 1c) of growth factor signaling demonstrates that TPO-enriched pathways (blue shaded) preferentially coded for proteins that are located in the plasma membrane. Note transcripts for proteins associated with mechanotranduction in the plasma membrane (integrins; dashed black circle) and corresponding cytoplasmic cytoskeletal components (actin; dashed black box).

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BMP-2 Increases Survival of Mesenchymal Stem Cells and Fracture Healing When Deployed in Photopolymerizable Hydrogels

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Purpose: Mesenchymal stem cells (MSCs) have great therapeutic potential for the repair of nonhealing bone defects due to their proliferative capacity, multilineage potential, trophic factor secretion, and lack of immunogenicity. However, a major challenge to the translation of cell-based therapies into bone regeneration constructs is ensuring their survival and function upon implantation. Composite constructs utilizing growth factors such as bone morphogenetic proteins (eg, BMP-2) and MSCs are under investigation for use in the clinic, yet the effect of BMP-2 delivery on MSC survival and function remains poorly studied. We investigated cell survival and subsequent effects on bone regeneration in MSCs codelivered with BMP-2. Our aim was to determine the efficacy and survival of MSCs when delivered with BMP-2 via a photopolymerized, modified alginate carrier in a rat critical size defect (CSD) model.

Methods: Diaphyseal CSDs (6 mm) were created in the right femora of 10- to 12-week-old male athymic rats and stabilized with a radiolucent PEEK (polyetheretherketone) plate and 6 angular stable bicortical titanium screws. Sodium alginate modified with methacrylate side chains, to enable photopolymerization, and Arg-Gly-Asp (RGD) peptide, to promote adhesion, was used as the carrier. Human MSCs genetically modified to express luciferase (3 x 106 cells/150 μL gel) were suspended in the gel, cross-linked (0.05% w/v photoinitiator 3.5 mW/cm2) for 30 min, and then incubated at 37ºC in α-MEM (minimum essential medium) up to 12 hours. Animals were randomly assigned to two treatment groups: (1) -BMP (alginate modified with the cell adhesive ligand sequence RGD) or (2) +BMP (RGD modified alginate containing 2 μg BMP-2). Persistence of transplanted cells was determined by whole body bioluminescence at 1, 2, and 4 weeks. Surveillance radiographs were obtained at 4, 8, and 12 weeks, and scored 0 (no bone formation), 1 (possible union), or 2 (union). All rats were sacrificed at 12 weeks.

Results: Bioluminescence was used to assay cell viability of transplanted cells within the defect (Figure 1A). Alginate hydrogels containing BMP-2 had significantly more cells at each time point than gels without BMP-2 (Figure 1B). All animals in the BMP group demonstrated 100% radiographic union by 8 weeks. None of the rats in the RGD group fully united at the time of sacrifice.

Conclusion: The delivery of BMP-2 in RGD-modified alginate gels increased MSC survival compared to alginate with MSCs alone, resulting in increased bone formation in a critical size defect model. The interplay between BMP and cell survival using photopolymerized hydrogel systems merits further study.

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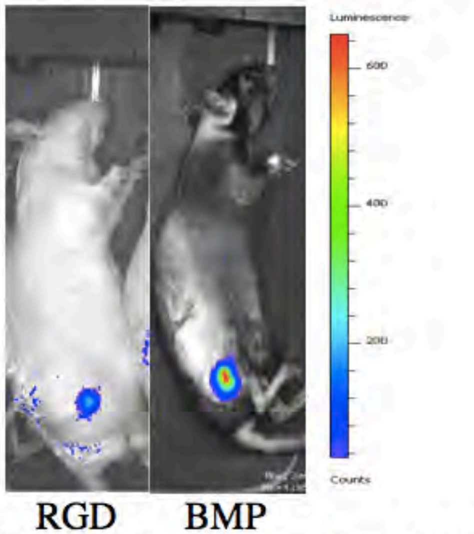

Figure 1A: Representative bioluminescence at 4 weeks.

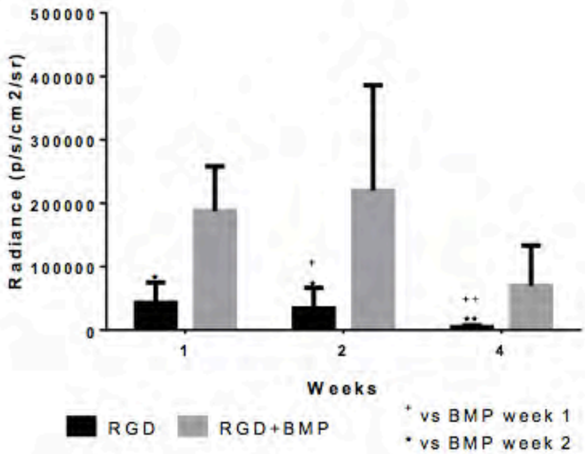

Figure 1B: Quantification of bioluminescence over time.
(P<0.05 at all time points)

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Controlled Axial Dynamization with a Novel Active Locking Plate Can Deliver Faster and Stronger Healing

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Background/Purpose: Controlled axial dynamization of a fracture promotes healing by callus formation, while overly stiff fixation constructs can suppress healing. A novel plating technology, termed active plating, has been developed that provides symmetric axial dynamization by elastic suspension of locking holes within the plate. This in vivo study evaluated the effect of dynamization with active plating technology on fracture healing in direct comparison to standard locking plates. We hypothesized that active plating delivers faster, stronger and more consistent fracture healing than standard locked plating.

Methods: Fracture healing was quantified in an established large animal model by stabilizing a 3-mm gap of the sheep tibia with bridge plating constructs. In 12 sheep, gaps were bridged with standard locking plates (LP group, n = 6) or active locking plates (ACTIVE group, n = 6). Both groups used titanium 4.5-mm locking plates and 5.0-mm locking screws. The only difference between groups was that locking holes of active plates were elastically suspended within the plate by means of a silicone envelope to provide controlled axial motion. Fracture healing was assessed weekly, starting at postoperative week 3, on anteroposterior and lateral radiographs to measure callus size and to detect bridging callus. Tibiae were harvested at week 9 postsurgery. Soft tissue in contact with active plates was evaluated for potential reaction to silicone. After implant removal, tibiae were biomechanically tested to failure to assess the strength of healing.

Results: At each time point from postoperative weeks 3 through 9, the ACTIVE group had significantly more callus ($P < 0.001$) than the LP group (Fig. 1). Already at the earliest time point (week 3), the average callus size in the ACTIVE group (296 ± 84 mm2) was over six times greater than in the LP group (47 ± 55 mm2). Six weeks postsurgery, all six sheep of the ACTIVE group had bridging callus at the lateral, anterior, and posterior cortices that are visible on planar radiographs. In the LP group, only 50% of these cortices had bridging callus. After sacrifice at week 9, no soft-tissue reaction to the silicone envelopes of active plates was detectable. Torsion testing demonstrated that tibiae of the ACTIVE group had healed to be 158% stronger and required 398% more energy to induce failure compared to the LP group ($P < 0.001$).

Conclusion: Due to their high stiffness, locked bridge plating constructs can suppress interfragmentary motion required for secondary fracture healing by callus formation. Conversely, by providing controlled axial dynamization, active locking plates delivered earlier callus formation, consistent bridging callus, and stronger healing than standard locking plates.

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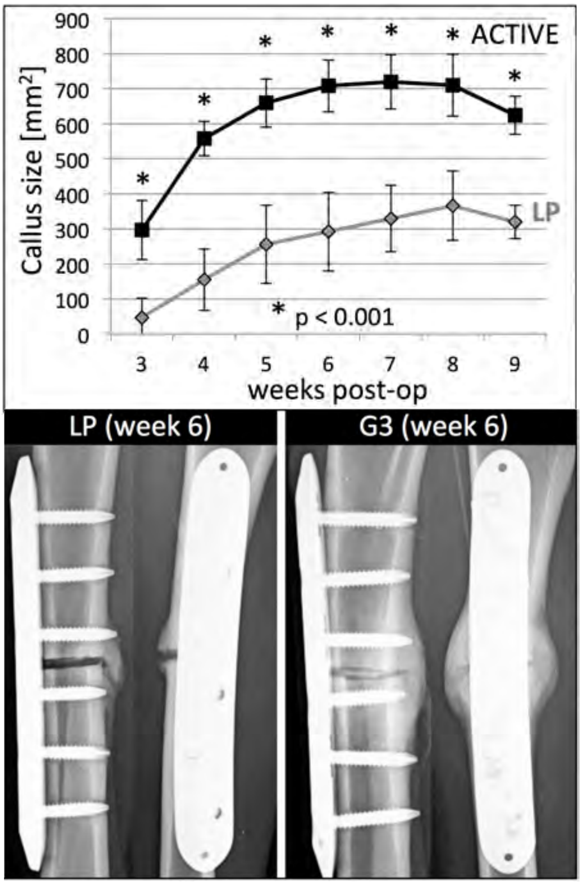

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A Biomechanical Comparison of Standard versus Far Cortical Locking Screws in a Periprosthetic Distal Femur Fracture

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Purpose: The incidence of periprosthetic fractures in the population continues to rise. As these patients are elderly and likely to have comorbid medical conditions, it is necessary to stabilize the fracture with fixation that will facilitate bone healing. Our purposes were: (1) demonstrate a periprosthetic fracture model that can be used for future studies and (2) biomechanically evaluate construct stiffness and fracture gap motion with periprosthetic plates comparing standard locking with far cortical locking screws in the diaphyseal segment.

Methods: Ten paired cadaveric femurs were obtained. The femurs had no prior implants. All femurs were determined to be osteopenic or osteoporotic by DXA (dual x-ray absorptiometry) scans. Specimens had a femoral total knee component placed to simulate a periprosthetic model. We then placed a 9-hole periprosthetic locking plate with either standard locking screws or far cortical locking screws in the diaphysis (holes 3, 5, 7, and 9). All plates were fixed distally with 5 standard locking screws. A distal femoral fracture was then created with a 1-cm lateral and 3-cm medial gap, simulating an extra articular periprosthetic fracture model. The osteotomies were standardized to ensure the gap level was identical in all constructs. Specimens were potted and loaded on the MTS machine and tested to axial failure. Stiffness of the construct and micromotion were recorded at the fracture gap.

Results: The standard locking screw (SS) construct stiffness was significantly higher when compared to the far cortical group (FC) ($P < 0.05$). The average micromotion in the FC group was 1.12 times higher than the SS group, but did not reach statistical significance ($P = 0.476$). All FC constructs failed at the far cortex of the most distal diaphyseal screw. All SS constructs also failed at the distal most diaphyseal screw, however, 6 of 10 failed on the side of the locked plate. Location of primary failure was significantly different between the two groups ($P = 0.010$).

Conclusion: Our periprosthetic fracture model demonstrates an FC construct was significantly less stiff than standard locked screws. Recent literature has suggested that decreasing the rigidity of the construct may aid fracture healing by allowing micromotion at the fracture site. In our model, no statistical significance was noted in micromotion, although the average motion at the fracture gap was higher in the FC construct than the standard locking screw construct. This information could be applied in consideration of controlling construct stiffness and possibly fracture healing.

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In Vivo Correlation of RUST Scoring with Biomechanical Strength of Nailed Tibia Fractures: Can We Finally Define Union Radiographically?

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Background/Purpose: The Radiographic Union Scale for Tibia fractures (RUST) is used to numerically report the progress to union after intramedullary nailing; however, there is currently no value that defines union. Additionally, the score has been evaluated in a wide range of fracture patterns treated with multiple nails and constructs. A modified score that allows for 4 scores per cortex has been described. The purpose of this study was to evaluate the standard RUST score and the modified RUST score in a large animal osteotomy model, and to evaluate the effect of canal visualization on the reliability of the RUST scores and the assessments of union. Most importantly, we sought to determine the standard and modified RUST scores that represent biomechanical union, based on the torsional stiffness of the affected versus the contralateral tibia in the animals.

Methods: Two groups of sheep had transverse midshaft osteotomies treated with locked 10-mm radiolucent carbon fiber (10) or radiodense titanium (10) nails after reaming to 11. 5mm. Weightbearing was allowed as tolerated. AP and lateral radiographs were taken at standard intervals from 4 to 12 weeks. The cortices of each tibia at each time interval were evaluated by 5 senior orthopaedic trauma surgeons in 2 separate sessions 8 weeks apart. Evaluations were made with the type of nail blinded and unblinded. Cortical callus was graded as "none," "present," "bridging," or "remodeled" for the modified RUST score. The middle two were collapsed to give a standard RUST score. The tibiae were randomly ordered for each surgeon. Additionally, each set of radiographs was graded as "healed" or "not healed." The absolute intraclass correlation coefficient (ICC) was determined for the standard and modified RUST score at each interval and for the assessment of union. The percentages of fractures that were defined as united were tabulated by standard RUST and modified RUST score. The torsional stiffness of each tibia was tested at 12 weeks and expressed as a percentage of the contralateral side. We considered biomechanical union to be equal to 90% of the torsional stiffness of the normal side.

Results: The modified RUST score demonstrated consistently higher ICC for all evaluations (Table 1). The ICC for union was higher for the radiodense than the radiolucent nail for both unblinded (0.89 vs 0.69) and blinded (0.80 vs 0.69) evaluations. The overall percentage of tibiae graded as united by the reviewers is seen in Table 2. The standard RUST was 10.3 (range, 8.6 - 12) and modified RUST was 14.1 (12.2 - 16) for tibiae that were biomechanically united.

Conclusion: This is the first study to evaluate the RUST scoring methods in a controlled animal model including a biomechanical evaluation. The ICC for the modified RUST is

better than the standard RUST in a standardized animal osteotomy model irrespective of nail material or canal blinding. This indicates that the modified RUST is a better tool for assessing the progress of union over time. The ICC for the assessment of union was higher for the titanium nail and reached excellent agreement (0.8 blinded and 0.89 unblinded). Biomechanical union averaged 10.3 and 14.1 for the RUST and modified RUST scores, which is consistent with the surgeons' evaluations.

Table #1: ICC's for Standard and Modified RUST Scores

RUST	Unblinded			Blinded		
	Carbon	Titanium	All	Carbon	Titanium	All
Standard	.73	.67	.70	.69	.67	.68
Modified	.82	.81	.81	.85	.84	.84

Table #2: Percentage of Reviewers Assigning Union by RUST Score (unblinded)

	RUST			Modified RUST			
Score	8	9	10	11	12	13	14
% United	7%	53%	100%	14%	35%	74%	100%

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The Biomechanical Advantage of Locked Versus Non-locked Symphyseal Plating of Unstable Pelvic Ring Injuries

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Background: Symphyseal plate systems for treating pubic symphysis diastasis in unstable pelvic ring injuries are available with locked and nonlocked capabilities. Locked plating systems were developed to improve postoperative stability and reduce the risk of failure, although a biomechanical advantage for locked symphyseal plating has yet to be experimentally demonstrated.

Methods: In this comparison of locked vs. nonlocked symphyseal plating during simulated single leg-stance loading of OTA 61-C 1.2 (unilateral sacroiliac joint disruption and pubic symphysis diastasis) fractures, 14 pelvic models were constructed and tested (Sawbones full pelvic models, foam with cortical shell). S1 sacroiliac screws (Synthes 7.3, cannulated, partially threaded) were inserted via standard technique under direct visualization and real-time fluoroscopy. Anterior fixation consisted of symphyseal plating (Synthes 3.5-mm, 6-hole, locked symphyseal plate) used in either a locked (7 models) or nonlocked fashion (7 models). The affected hemipelvis was supported by an articulating femoral head and wire cables tensioned to recreate the effects of the abductor musculature. A contralateral load of 80 N was used to simulate the weight of the contralateral limb. Each model was cyclically loaded through the sacrum to a maximum of 350 N at 1 Hz for a total of 1000 cycles, representing the biomechanics of single leg stance. A series of markers were placed along each side of the pubic symphysis. Motion of each marker was tracked using a video-based 3-dimensional tracking system. Relative motion was measured between opposing markers across the symphysis in regards to gap formation, shear along the symphysis, and along an axis perpendicular to the other two (anterior translation of the unsupported hemipelvis at the symphysis).

Results: Anterior translation at the end of cyclic loading was larger for the nonlocked models than the locked models. At the onset of loading, average (± standard deviation) anterior translations for the non-locked and locked models were 1.6 ± 0.5 mm and 1.2 ± 0.5 mm, respectively ($P = 0.182$). At 1000 cycles, the anterior translations for the nonlocked and locked models were 2.3 ± 0.6 mm and 1.4 ± 0.6 mm, respectively ($P = 0.015$). No significant differences were identified for gap formation or shear motion ($P > 0.3$).

Conclusion: The results indicate that locked plating of symphyseal injuries provides a more stable construct for repetitive loading.

The Effect of Varying Tension of a Suture Button Construct in Fixation of the Tibiofibular Syndesmosis: Evaluation Using Stress Computed Tomography (CT)

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Background/Purpose: Traditional screw fixation of the syndesmosis can be prone to malreduction. Suture button fixation, however, has recently shown potential in securing the fibula back into the incisura even with intentional malreduction. Yet, if there is sufficient motion to aid reduction, the question arises whether or not this construct is stable enough to maintain reduction under loaded conditions. To date, there have been no studies assessing the optimal biomechanical tension of these constructs. The purpose of this study was to assess optimal tensioning of suture button fixation and its ability to maintain reduction under loaded conditions using a novel stress CT model.

Methods: Eight cadaveric lower limbs disarticulated at the knee were used. The limbs were placed in a modified external fixator jig that allows for the application of sustained torsional (5 Nm), axial (500 N), and combined torsional/axial (5 Nm/500 N) loads. Baseline unloaded and loaded CT scans were obtained. Bone tunnels were predrilled to pass the suture button devices prior to sectioning of the syndesmosis, ensuring no malreduction prior to drilling. The syndesmosis and the deltoid ligament complex were then sectioned. The limbs were then randomized to receive a suture button construct tightened at 4 kg force (loose) or 8 kg (standard tightness). Four measurements were taken from axial slices 10 mm above the tibiotalar joint: a measure of medial/lateral translation (ML), a measure of anterior-posterior translation (AP), a ratio of anterior-posterior translation (d/e), and an angle created by a line parallel to the incisura and the axis of the fibula (angle). For AP and ML, a positive number indicates movement in the anterior and medial directions. For the d/e ratio, a negative value signifies the fibula was translated posteriorly. A positive value for fibular angle indicates external rotation.These measurements have all been previously described. Each measurement was taken at baseline and compared with the 3 loading scenarios. A repeated-measures analysis of variance with a Bonferroni correction for multiple comparisons was used to test for significance.

Results: The mean difference between the baseline repaired and stressed repaired specimens is shown in Figure 1a. Significant posterior translation was seen in the 4 kg group with axial loading when measurement AP was compared. Additionally, ratio d/e showed significant posterior translation in both the 4 kg and 8 kg groups under torsion and combined loads. There was significant external rotation of the fibula under axial load in the 4 kg group when compared with baseline scans. Additionally, when compared with the 8 kg group, the 4 kg group showed significantly more external rotation under the same torsional load (12.03° vs 8.63°). Both groups showed a trend of increasing external rotation especially under torsional loading.

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Conclusion: Stress CT demonstrated notable motion with a suture button fixation construct, especially under torsional loads. Care should be taken to ensure that this construct is properly tensioned and loads should be minimized until healing has occurred.

Figure 1a.

		Fixed at 4kg	Fixed at 8kg
AP (mm)	**Baseline**	-	-
	Axial	**-1.68 (2.05) ***	-1.70 (1.06)
	Torsion	2.78 (10.56)	0.4 (6.36)
	Combined	2.42 (10.09)	1.08 (6.08)
ML (mm)	**Baseline**	-	-
	Axial	0.17 (0.71)	-0.1 (1.05)
	Torsion	0.97 (3.20)	0.59 (1.77)
	Combined	0.65 (2.55)	0.34 (1.75)
d/e	**Baseline**	-	-
	Axial	-0.39 (0.72)	-0.32 (0.59)
	Torsion	**-1.53 (0.45) ***	**-1.55 (0.55) ***
	Combined	**-1.48 (0.45) ***	**-1.25 (0.53) ***
Angle (degrees)	**Baseline**	-	-
	Axial	**0.27 (2.82) ***	3.22 (6.22)
	Torsion	**12.03 (3.75)****	8.53 (3.51)
	Combined	10.78 (4.55)	9.87 (4.24)

* p<0.05 when compared with a non-stressed repaired baseline
** p<0.05 when compared with the 8 kg repair group

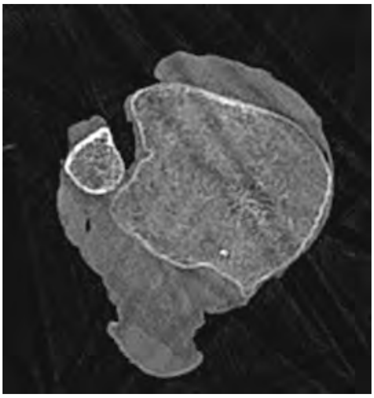

Figure 1b. - Axial CT scan. Shows a cadaveric specimen with a syndesmotic injury repaired with a suture button under 4kg tension with a combined torsion and axial load applied.

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Anatomic Ligament Repair Restores Ankle and Syndesmotic Rotational Stability as Much as Syndesmotic Screw Fixation

Name Credentials
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Purpose: Unstable rotational ankle fractures with concomitant syndesmotic disruption commonly occur. Currently, there is disagreement about the optimal treatment method for the syndesmotic injury component in this patient population. While transsyndesmotic screws are most often used, alternative syndesmotic stabilization strategies such as syndesmotic suture fixation and anatomic ligament repair have garnered increased interest. To date, no study has investigated the ability of an anatomic ligamentous repair strategy, consisting of posterior inferior tibiofibular ligament (PITFL) and deltoid ligament repair, to restore ankle and syndesmotic stiffness. Our hypothesis was that the anatomic ligament repair strategy would provide equivalent ankle and syndesmotic stiffness compared to a single 3.5-mm transsyndesmotic screw.

Methods: Nondestructive external rotation stresses of 4 nM were applied to 8 cadaveric limbs using a hydraulic loading frame. Four conditions were tested using a repeated-measures design: intact and three repair conditions following a destabilizing ligamentous ankle injury with syndesmotic disruption. The three repair conditions were tricortical transsyndesmotic screw fixation, PITFL repair, and combined PITFL and deltoid ligament repair. External rotation of the ankle and syndesmosis were measured using a motion capture system and compared for each test condition. Repeated-measures one-way analysis of variance (ANOVA) statistical tests were performed to compare the ankle and syndesmotic rotation findings between the three repair conditions and intact condition.

Results: Ankle stability was not fully restored by any of the three repair constructs. The intact ankle externally rotated approximately half as many degrees as the three repair conditions (Intact 10.9, Transsyndesmotic screw 17.0, PITFL 21.4, and PITFL/deltoid 15.6). Direct comparison between the transsyndesmotic screw and PITFL/deltoid repair specimens was not significantly different (P = 0.84). The intact condition demonstrated significantly fewer degrees of syndesmotic rotation than the repair constructs (Intact 2.4, Transsyndesmotic screw 5.2, PITFL 8.5, and PITFL/deltoid 6.9). Direct comparison between the transsyndesmotic screw and PITFL/deltoid repair groups was not significantly different (P = 0.21). Each of the repair constructs resulted in an externally rotated fibula compared to the intact condition prior to external rotation testing. The soft-tissue repairs (PITFL 4.3°, PITFL/deltoid 3.9°) caused twice as much external rotation compared to the syndesmotic screw (1.9°).

Conclusion: We found that combined repair of the PITFL and deltoid ligament restores an equivalent amount of ankle and syndesmotic rotational stability as transsyndesmotic screw fixation. Based on our findings, ligamentous repair can potentially be a viable treatment alternative in unstable ankle fracture patients with syndesmotic disruption. However, the

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clinical implications of a 2° greater fibular external malrotation with the ligamentous repair constructs compared to a single trans-yndesmotic screw is not known. Clinical outcome studies are needed to verify our biomechanical findings.

Table I. Summary and comparison of ankle and syndesmotic external rotation stability as well as resting fibular external rotation between intact and repair conditions

	Mean (n=8)	95% Confidence Intervals	P-value
Ankle Stability (degrees)			
Intact	10.9	6.4 – 15.4	-
Screw	17.0	11.4 – 22.6	0.008
PITFL	21.4	14.8 – 28.0	<0.001
PITFL+Deltoid	15.6	10.8 – 20.4	0.05
Syndesmotic Stability (degrees)			
Intact	2.4	1.6 – 3.2	-
Screw	5.2	3.6 – 6.8	0.013
PITFL	8.5	6.0 – 11.0	<0.001
PITFL+Deltoid	6.9	5.2 – 8.6	<0.001
Fibular External Rotation (degrees)			
Intact	-		-
Screw	1.9	1.0 – 2.9	0.016
PITFL	4.3	3.0 – 5.5	<0.001
PITFL+Deltoid	3.9	2.7 – 5.1	<0.001

Initial Stiffness of Bicortical Locked Screw Versus Unicortical Locked Screw and Graft-Cable Fixation of Comminuted Vancouver C Periprosthetic Fractures: A Biomechanical Study

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Background/Purpose: Periprosthetic fractures are estimated to occur in 1% to 6% of patients who have undergone total or hemiarthroplasty of the hip. The treatment that is considered by many to be the "gold standard" for Vancouver C periprosthetic fractures is fixation with a locked plate using unicortical screws and cables with or without an allograft strut. With the recent advances in polyaxial locking technology; we sought to determine the stiffness of this construct in comparison to bicortical locked-screw fixation around the implant stem in an osteoporotic, biomechanical model.

Methods: 20 synthetic osteoporotic femoral models were implanted with a noncollared, press-fit hip stem. After the stem was seated through traditional impaction, the stem was further subsided by 100 cycles of 1000 N at 1 Hz on a uniaxial servohydraulic testing machine. A 5-cm section of femoral diaphyseal bone was then removed 2 cm distal to the hip stem to simulate a Vancouver C periprosthetic fracture with severe comminution. An anatomic, proximal femoral, locking plate was then applied to each model with four bicortical, locked screws in the distal segment and 3-mm spacers between the plate and bone to simulate soft-tissue interposition. Specimens were then divided into four groups of five depending on the proximal segment fixation: (A) three polyaxial, locked bicortical screws anterior to the hip stem; (B) three polyaxial, locked bicortical screws posterior to the hip stem; (C) three alternating polyaxial, locked bicortical screws with two posterior and one anterior to the hip stem; and (D) three unicortical locked screws with a femoral allograft strut held in place by two proximal and two distal circumferential, braided-steel cables. Each specimen was then placed at 25° of adduction in a mounting fixture under a uniaxial servohydraulic testing machine. A preload of 50 N was applied followed by application of a 250-N load at 50 N per second. The process was then repeated with the specimen at 10° from the horizontal, in the coronal plane, using a load of 50 N at 10 N per second to simulate torsion during standing. This process was repeated in triplicate for each specimen. Load was assessed using the uniaxial servohydraulic testing machine and medial cortical displacement was assessed at the fracture gap using an optical tracking device.

Results: The highest axial stiffness was documented in group D, which was significantly higher than groups A through C ($P < 0.0001$ for all) (Table 1). The axial stiffness of groups B and C were not significantly different ($P = 0.1197$), but both were significantly greater than group A (Group B: $P = 0.0227$; Group C $P = 0.0014$). The highest torsional stiffness was also documented in group D, which was significantly higher than groups A through C ($P < 0.001$ for all) (Table 1). The torsional stiffness of group C was also significantly higher than both group A ($P = 0.0208$) and group B ($P = 0.0003$).

See pages 47 - 108 for financial disclosure information.

Conclusion: In a comminuted Vancouver C fracture model, proximal fixation with unicortical screws, cables, and a femoral strut graft provided the highest initial stiffness in both axial and torsional stiffness, despite greater variation between specimens. If locked plate fixation is used, placement of bicortical screws both anterior and posterior to the stem should be utilized to provide maximum torsional and axial stiffness.

Table 1. Initial Construct Stiffness in Axial and Torsional Testing

Method	Construct	n	Mean	St. Dev.	Min	Max
Axial	Anterior (A)	5	440.39	35.68	388.81	480.23
	Posterior (B)	5	591.48	22.28	558.23	632.84
	Alternating (C)	5	596.67	52.84	516.99	657.11
	Cable-Graft (D)	5	829.09	71.72	713.51	939.26
Torsion	Anterior (A)	5	46.31	4.71	37.03	53.06
	Posterior (B)	5	44.44	3.35	40.13	49.24
	Alternating (C)	5	53.51	4.03	48.41	62.44
	Cable-Graft (D)	5	82.11	15.76	56.67	100.94

Comparison of Three Methods for Maintaining Interfragmentary Compression After Fracture Fixation

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Background/Purpose: Intra-articular distal femur fractures are often stabilized with hybrid constructs (locking and nonlocking fixation) after fracture reduction. Generally, it is thought that lag screw fixation should precede any positional screw or locking screw application. The purpose of this study is to compare three different methods of maintaining interfragmentary compression after reduction and compression of the fracture with a reduction clamp.

Methods: Femur Sawbones (Pacific Research Labs) had an intra-articular vertical split fracture created using a jig and bandsaw. A pressure transducer (FlexiForce, Tekscan) was then placed in the fracture between the medial and lateral femoral condyles, and a pointed peri-articular reduction clamp was then used to compress the intra-articular split to approximately 20 lb of pressure in all specimens. 3.5-mm cortical lag screws (group 1), 3.5-mm cortical position screws (group 2), and 5.4-mm distal locking screws through a distal femur locking plate (group 3) were then placed across the fracture using standard technique and a torque limiting screw driver (lag and positional screws at 2 Nm, locking screws at 4 Nm). There were four specimens per group. The clamp was then removed and the amount of residual interfragmentary compression was measured. After 2 minutes a steady state was reached and the pressure was measured again. Statistical analysis was performed using Kruskall-Wallis analysis of variance for the initial force after clamp removal and Wilcoxson signed rank test for comparing baseline pressure to steady state pressure. Significance was set for P values less than or equal to 0.05.

Results: There was no significant difference between the three groups with respect to initial force applied with the clamp. Locking screws placed through the plate (group 3) maintained 27% of the initial force applied by the clamp ($P = 0.043$), positional screws maintained 90% of the initial force applied by the clamp (not significant), and lag screws increased by 240% the initial force applied by the clamp ($P = 0.043$).

Conclusion: When reducing intra-articular fractures and applying interfragmentary compression with reduction clamps, additional lag screws significantly increase the amount of compression seen at the fracture interface. Compressing a fracture with reduction clamps and relying on only locking screws through a plate results in a significant loss of interfragmentary compression, and should be avoided--particularly when treating intra-articular fractures. This study lends biomechanical support to the notion that hybrid techniques (lag screws before locking screws) for fracture fixation help to maintain optimal interfragmentary compression.

See pages 47 - 108 for financial disclosure information.

Periprosthetic Supracondylar Femoral Fractures Following Knee Arthroplasty: A Biomechanical Comparison of Four Methods of Treatment

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David Backstein, MD, MEd, FRCSC; Thomas Willett, PhD; Paul Kuzyk, MD, MASc, FRCSC;
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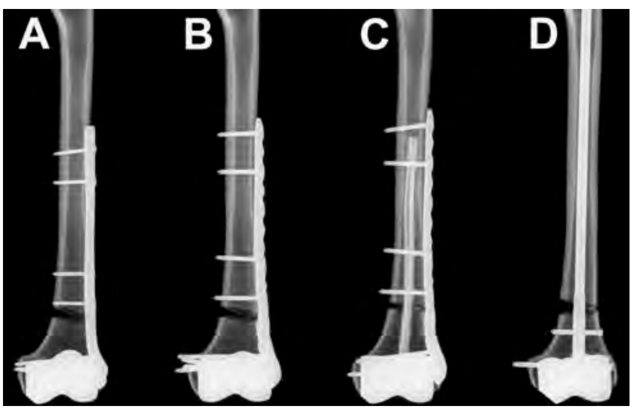
Purpose: Controversy exists over the optimal fixation of distal periprosthetic femoral fractures. The purpose of this study was to determine the biomechanical stability of a periprosthetic supracondylar femur fracture stabilized with either a nonlocking plate, a polyaxial locking plate, a polyaxial locking plate augmented with an intramedullary fibular strut graft, or a retrograde intramedullary nail. We hypothesized that the polyaxial locking plate augmented with an intramedullary fibular strut graft would provide improved fixation of the distal femoral fragment compared with the intramedullary nail or polyaxial locked plate alone.

Methods: Twenty large-sized fourth-generation composite femurs (Sawbones, Pacific Research Laboratories) simulating osteoporotic human bone were used in this study. A NexGen LPS-Flex femoral component was implanted on all the specimens using bone cement. The specimens were divided to 4 groups (5 specimens in each group): A, nonlocking plate (Zimmer Periarticular Plating System); B, polyaxial locking plate (Zimmer NCB Periprosthetic Femur Plate System); C, polyaxial locking plate augmented with an intramedullary fibular strut allograft (Zimmer NCB Periprosthetic Femur Plate System); and D, retrograde intramedullary nail (Zimmer Natural Nail System) (Fig. 1). Following instrumentation, a metaphyseal-diaphyseal defect was created simulating an AO/OTA 33-A3 fracture pattern. The specimens were mounted on an Intron ElectroPulse E10000 universal mechanical testing machine. In nondestructive cyclic loading, each specimen experienced 10 cycles of 200 N to 500 N axial load. This was followed by 10 cycles of torque between +8 Nm and -8 Nm superimposed on 200 N of static axial load. Following cyclic loading, each specimen was quasistatically loaded axially at 10 mm/min deformation rate until specimen failure.

Results: The polyaxial locking plate augmented with an intramedullary fibular strut graft showed the highest rigidity under cyclic torsional loading while the intramedullary nail had the lowest torsional rigidity. No differences were detected in the cyclic axial loading between the constructs. During quasistatic axial loading to failure, the intramedullary nail achieved the highest axial stiffness while the nonlocking plate showed the lowest. The polyaxial locking plate with strut graft displayed an axial stiffness lower than the intramedullary nail, but equal to the stiffness of polyaxial locking plate only or nonlocking plate.



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.

Conclusion: This report is the first to examine fixation methods in a periprosthetic supracondylar fractures using an osteoporotic bone model. Based on the results, the polyaxial locking plate augmented with an intramedullary fibular strut graft yielded the highest torsional stiffness. The nonlocked plate showed the lowest strength and therefore should be avoided especially in comminuted fracture patterns.

See pages 47 - 108 for financial disclosure information.

Axial and Rotational Malreduction (Golf Club Deformity) in Distal Femur Fractures

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Background/Purpose: Open reduction and internal fixation of fracture have helped trauma patients to mobilize early for decades. The procedure helped in restoring the limb mechanics to close to their original state. Precontoured lateral condylar locking plates have been increasing in popularity as a method for stabilizing distal femur fractures since their development. They provided an edge to other methods by accounting for the natural contour of the distal femur. But despite their advantages, some studies have shown associated malunion rates between 11% and 26%. A specific problem in recent years have been described as a malreduction and medialization of the articular block, sometimes referred to as golf club deformity. The purpose of this study is to define the so-called "golf club deformity" and test a hypothesized solution. The authors hypothesize that the golf club deformity is a combined medial translation and axial external rotation which occurs when the plate is placed using current methods, and that placing the plate in a better anatomic position by placing it in 10° of external rotation, thus accounting for the normal slope of the lateral distal femoral condyle, should lower the malunion rates.

Methods: A supracondylar distal femur fracture model was created (AO/OTA 33A) using 7 fresh-frozen cadaver femurs. All femurs were radiographed prior to testing to ensure no previous fractures. An 8-hole, lateral distal locking femoral plate (Stryker) was placed flush to the lateral femoral condyle (Group I) and then reduced to the shaft (Fig. 1). In Group II, the anterior flange of the plate was externally rotated 10° in relation to the lateral condyle (Fig. 1). Optical motion capture (Max Pro optical tracking system, Innovision Systems) measured translation and rotation of the articular segment as screws were tightened and the plates were reduced to the femoral diaphysis. Since both configurations were applied to each bone, paired Student t test was used to compare the differences in measures of malreduction. The authors used a large database of 800 samples (Stryker Orthopedic Modeling and Analytics technology "SOMA") to confirm the anatomic alignment of the lateral femoral condyle.

Results: Average medial displacement of the articular block was 17.1 ± 10.4 mm vs 9.3 ± 4.7 mm for groups I and II, respectively (P = 0.02). Therefore, the average reduction in medial translation from group I to group II was 7.8 ± 6.8 mm. Plate external rotation in Group II improved medial translation by 46%. Average anterior displacement was 6.0 ± 4.3 mm vs 2.1 ± 1.2 mm for groups I and II, respectively (P = 0.08). Therefore, the average reduction of anterior translation was 3.9 ±4.9 mm and represented a 65% improvement in sagittal plane translation. Average external rotation was 12.2° ± 3.6° vs 2.5° ± 2.0° for groups I and II, respectively (P = 0.002). Therefore, the average reduction of axial external rotation was 9.7° ± 4.7°, representing an 80% improvement in axial malrotation. Looking at SOMA's database the authors found that the angle of the lateral distal femoral condyle has a mean posterior anterior inclination of 16.5° (Fig. 2).

Conclusion: Data presented here demonstrate significant medial translation (17 mm) and external rotation (12.2°) despite appropriate plate placement, as described in the literature. Placing the plate in 10° of external rotation was noted to largely, but not completely, correct the malalignment. Future studies will investigate other means of correcting the malalignment, especially considering the 16.5° posterior anterior inclination of the condyle.

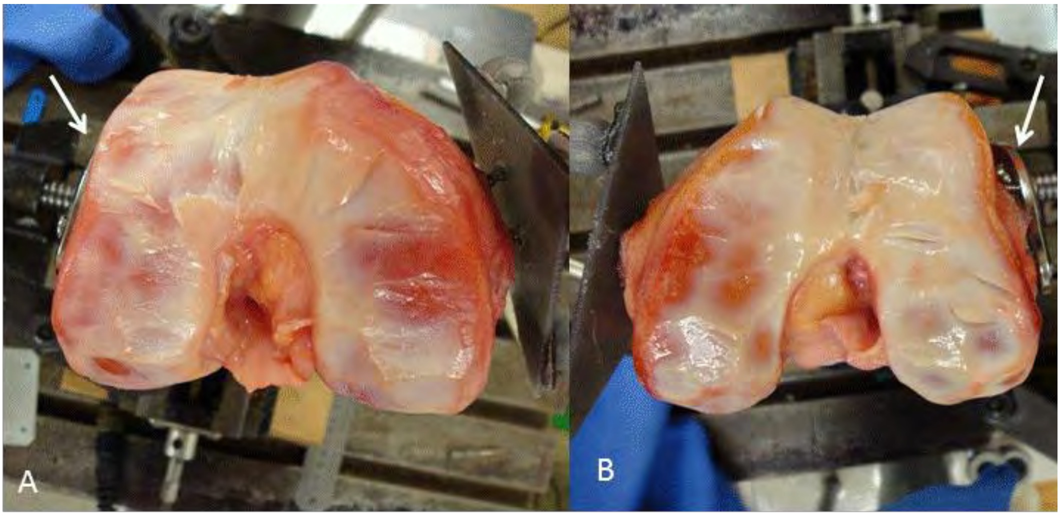

Figure 1: Photos of a speciemen from each group. A) Group I illustrates placement of the distal foot print flush to the lateral cortex (white arrow). B) Group II demonstrates external rotation of the distal foot print as indicated by the anterior flange sitting off the lateral cortex (white arrow).

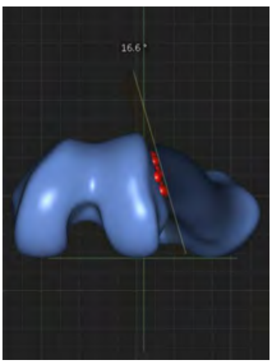

Figure 2: 3-D model showing the average degree of the distal femur inclination

See pages 47 - 108 for financial disclosure information.

Autologous Minced Muscle Treatment of Volumetric Muscle Loss Improves Neuromuscular Strength

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Background/Purpose: The volumetric loss of skeletal muscle has no definitive therapy and the resultant functional deficits are often considered part of the sequelae of severe musculoskeletal trauma. Volumetric muscle loss (VML) can occur directly or indirectly after various injury mechanisms (blast, crush, degloving) or surgical procedures (debridement, tumor removal, and muscle tissue resection). For example, VML occurs with type III open fractures and often results in suboptimal function of salvaged limbs. The pathophysiology of VML is not well understood. Moreover, therapeutic strategies to regenerate de novo functional muscle tissue are not established. The purpose of this study was twofold: (1) to develop a porcine model of VML to evaluate the pathophysiology of VML and (2) to investigate the capacity of autologous minced muscle grafts (1 mm3 pieces of muscle) as a therapeutic to restore muscle strength. Minced muscle grafts were chosen for this study because they are an effective therapy in rat VML studies and do not require FDA (US Food and Drug Administration) approval for clinical use.

Methods: A bilateral VML model was established in the anterior compartment of the leg in female Yorkshire Cross pigs. In five pigs, approximately 5 g of tissue was excised from the middle third of the peroneous tertius muscle (~3 cm x 3 cm x 1.5 cm volume) in each leg. In each pig, the defect in one leg was treated with autologous minced muscle (~1 mm3 pieces, derived from contralateral defect) and the contralateral defect was untreated. The fascia and skin were closed similarly in all conditions. The animals were allowed to recover for 12 weeks. Prior to injury, and every 2 weeks postinjury, in vivo muscle function was performed to assess the strength of dorsiflexor muscles (tibialis, digitorum, peroneous tertias) using a large animal force transducer (890A, Aurora Scientific). While under anesthesia, the foot of the nonrepaired leg was attached to a foot-plate of the force transducer with the foot plantar flexed and the knee at a right angle. Maximal isometric tetanic torque was elicited by stimulating (100 Hz, 0.1 ms pulse, 800 ms train) the peroneal nerve with percutaneous needle electrodes. On the final day of testing, muscles were harvested, weighed, and prepared for standard histology. This study was conducted in compliance with the Animal Welfare Act, the implementing Animal Welfare Regulations, and the principles of the Guide for the Care and User of Laboratory Animals.

Results: Over the course of the 12-week study, pigs significantly gained body weight (preinjury vs 12 weeks; 39.9 ± 1.5 vs 69.2 ± 1.9, $P < 0.001$). Therefore, isometric muscle strength was normalized to body weight to control for growth. Group strength deficits to VML injury are presented in Figure 1A. Ultimately, VML injury resulted in a ~40% loss of neural-evoked strength 12 weeks postinjury in nonrepaired legs. VML repair with autologous minced muscle grafts resulted in significantly improved strength at this time (~20% strength deficit, $P < 0.001$). Histologic analysis indicates that nonrepaired VML-injured muscles develop significant fibrosis and present no evidence of muscle fiber regeneration within the defect area (Figure 1B). In comparison, autologous minced graft treated muscles presented evidence of de novo muscle fiber regeneration within the defect area, although collagenous tissue deposition was also present.

Conclusion: Volumetric muscle loss presents persistent strength deficits marked by severe fibrosis. Autologous minced muscle grafts restored approximately 50% of the strength deficit observed in nonrepaired muscle and presented histologic evidence of muscle tissue regeneration within the defect area. Although many challenges remain in maximizing functional recovery and muscle tissue regeneration after VML, these results encourage the clinical application of autologous minced muscle graft-based repair strategies for severe soft-tissue trauma.

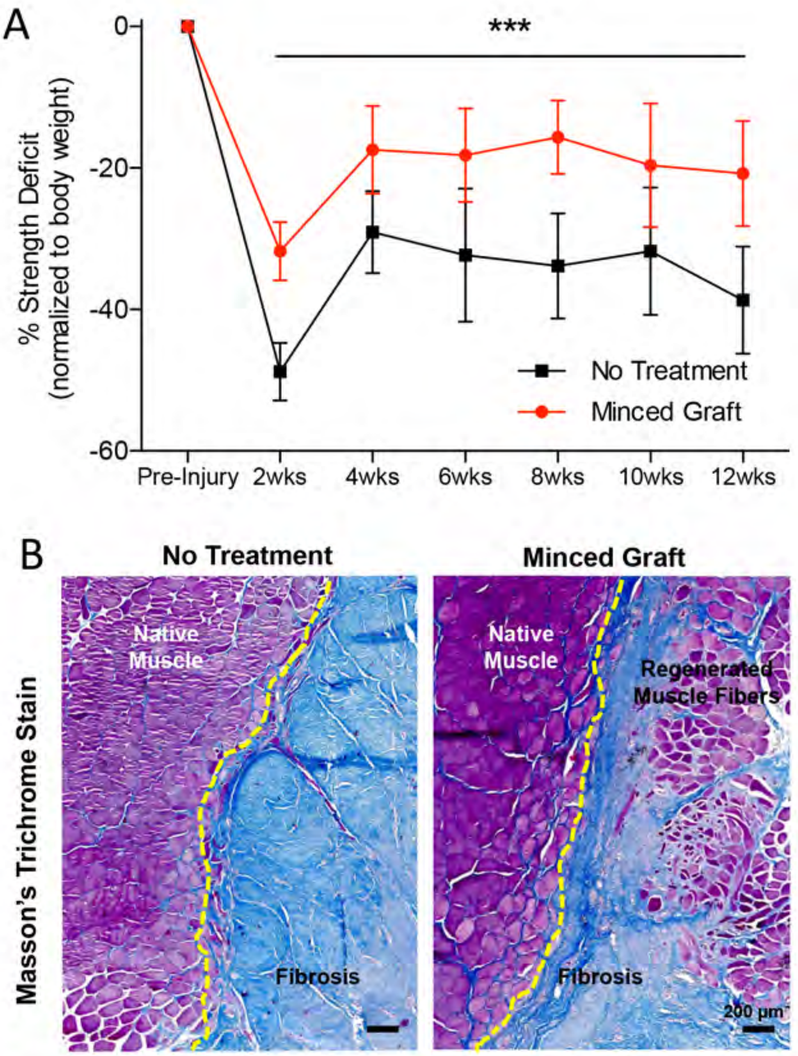

Figure 1. Autologous minced muscle graft-repair of VML in a porcine model. VML injuries were surgically created in the anterior crural muscle compartment of each leg (n = 5 pigs). One VML defect received no treatment, while the contralateral leg was treated with autologous minced muscle grafts (1 mm3 pieces of muscle). A) In vivo isometric muscle strength of the affected musculature was assessed every two weeks in each leg. At all time points post-injury, the minced muscle graft group was significantly stronger than non-repaired muscles. Values are mean ± sem; *** Minced Graft > No Treatment, $p < 0.001$. B) Representative histological images of the interface the remaining muscle mass and VML defect region 12 weeks post-injury (denoted by dashed line).

See pages 47 - 108 for financial disclosure information.

Comparison Between Suprapatellar and Parapatellar Approach for Proximal Tibia Fractures: A Cadaveric Study

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Background/Purpose: Fractures of the tibia with a short proximal fragment are more difficult to nail than midshaft fractures. One solution to this problem is tibial nailing with the knee in a semi-extended position, with a suprapatellar or parapatellar approach to help achieve correction of the malalignment. Parapatellar approach for tibia nailing is a safer approach and less injurious to intra-articular structures of the knee than the suprapatellar approach: however, the parapatellar approach in the majority of the cases is an intra-articular procedure.

Methods: Paired legs from 10 fresh-frozen cadavers were used. There were no previous injures or surgeries on the knees of the cadavers. An arthroscopy was performed in each knee, documenting the status of the knee prior to the insertion of the nail. In a random manner, the left or right leg was nailed with a supra- or parapatellar approach. The legs were positioned in 20° to 40° of knee flexion. Fluoroscopy was utilized in each case to localize the entry point, the tibia was reamed, and a titanium tibia nail was inserted in all cases. Once the nail was inserted, an arthrotomy was performed and the status of the following structures was assessed: patella cartilage, trochlea cartilage, tibia plateau cartilage, intermeniscal ligament, lateral and medial meniscus, and the ACL (anterior cruciate ligament). The distance was measured from the entry point to lateral and medial meniscus, to the intermeniscal ligament and to the ACL.

Results: The correct fluoroscopy entry point was achieved in 100% of the specimens for both the supra- and parapatellar approaches. Two-thirds of the legs with parapatellar approach had intra-articular disruption. In legs with a suprapatellar approach, patellar cartilage damage and trochlea cartilage damage was found in 30% and 20% of the specimens, respectively. There was no cartilage damage in the parapatellar approach. There were no meniscal injuries. Partial laceration of the intermeniscal ligament was found in 30% of the knees with suprapatellar approach and 15% of the knees with parapatellar approach. The ACL was intact in 96% of the specimens. The suprapatellar approach, on average had a closer entry point to the meniscus than the parapatellar approach.

Conclusion: A good fluoroscopic entry point can be achieved using either the parapatellar or suprapatellar approach. The parapatellar approach for tibia nailing has less cartilage damage and less soft-tissue damage than the suprapatellar approach. The majority of specimens with a parapatellar approach do enter the knee joint. The parapatellar approach is safer around the knee than the suprapatellar approach, and very meticulous technique should be used in cases when the suprapatellar approach is unavoidable.

Blind Area of Reverse-L Posteromedial Approach Compared with Posterolateral Approach for Posterolateral Tibial Plateau Fractures: A Cadaveric Study

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Background/Purpose: Fractures involving the posterolateral (PL) tibial plateau are surgically challenging. The reverse-L posteromedial (R-PM) approach is commonly used for anatomic reduction and fixation of a posterior tibial plateau fracture. This approach provides adequate exposure to the PM and posterior area of the medial tibial plateau, but some parts of the PL tibial plateau cannot be accessed, especially in patients with large muscle mass. The PL approach without fibular osteotomy allows direct access to the PL articular surface for PL buttress fixation. No published studies have explored the blind area of the R-PM approach compare with the PL approach. The aim of this study is to compare the surgical exposure area between the R-PM approach versus the PL approach using the lateral plateau width as a guide for choosing the correct surgical approach for fractures involving the PL tibial plateau.

Methods: Ten fresh-frozen cadavers with 20 lower extremities were included. The R-PM approach was done and the boundary of the articular surface and posterior cortex exposure were marked with metal pins. After that, the PL approach was performed and the exposure area was similarly marked with metal pins. After removing all soft tissue, an imaginary line was drawn from the lateral plateau rim locating anterior to fibular head (L) to the PM ridge of tibia (M). The bony reference landmarks on the lateral tibial plateau including the lateral tibial spine (S), the lateral boundary of PM approach (LPM), the medial boundary of PL approach (MPL), and the lateral boundary of PL approach (LPL) were marked with metal pins. The distances between L and S (A) refer to lateral tibial plateau width; S to LPM (B); and LPL to LPM (C). AP radiographic studies of the proximal tibia were done and the same distances were measured.

Results: The average percentage of distance from S to LPM (B), S to MPL, S to LPL, and MPL to LPL was 43.72% (95% confidential interval [CI]: 38.61%-48.82%), -53.22% (95% CI: -57.95% to -48.49%), 81.41% (95% CI: 77.21%-85.61%), and 120.54% (95% CI: 113.56%-127.53%) of lateral plateau width, respectively. (See accompanying figures.) The average distance from L to S (A) was 32.62 mm (standard deviation = 2.19; (range, 27.73 to 36.01). The average percentage of blind distance of R-PM from LPM to LPL (C) was 58.45% (95% CI: 51.48%-65.41%) of lateral plateau width. Distance L to LPL which represents the invisible distance of both approaches located on approximately 15.37% (95% CI: 10.59%-20.16%).

Conclusion: The PL approach provides more access to the lateral tibial plateau than the R-PM. The blind area of R-PM starts approximately 43.72% and then ends at 81.41% from the lateral tibial spine. When the fracture is located more than 43.72% of the posterior lateral plateau width, it is recommend to use the PL approach.

Figure 1: Illustration of surgical approach and visible boundary measurement

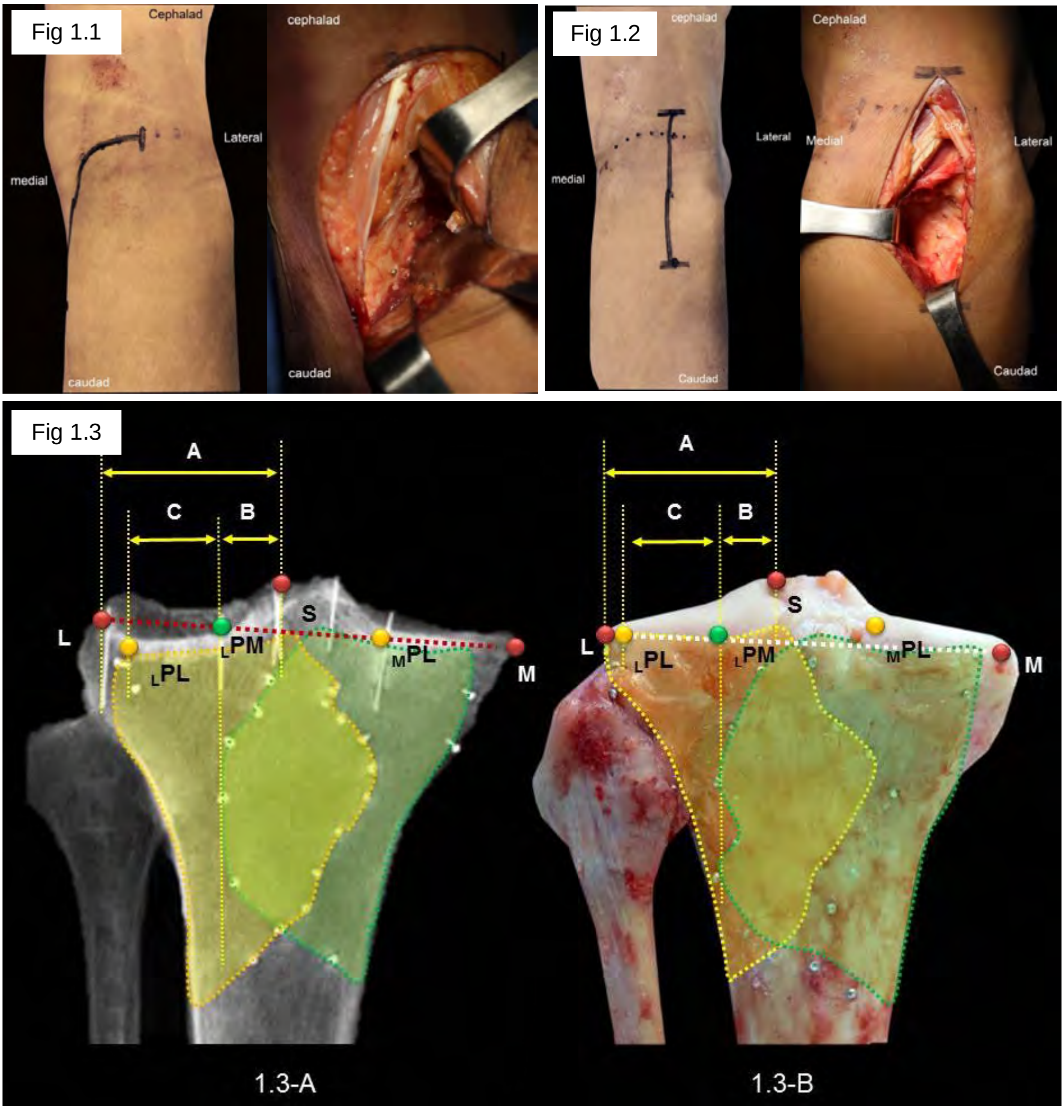

Figure 1.1, 1.2 Reverse-L posteromedial approach (1.1), posterolateral approach (1.2)

Figure1.3 :	The measurement methods of the reversed L-incision of posteromedial approach visible boundary and the posterolateral approach visible boundary
1.3-A :	Plain radiography of tibial plateau marked with metal pins
1.3-B :	Posterior aspect of tibial plateau marked with metal pins
A	Lateral tibial plateau width (L to S)
B	Lateral tibial plateau area which could be accessed via R-PM (S to $_L$PM)
C	The blind area of R-PM ($_L$PL to $_L$PM)
L to $_L$PL	The blind area of both R-PM and PL

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.

The Safety and Feasibility of Minimally Invasive Plate Osteosynthesis (MIPO) on the Medial Side of the Femur: A Cadaveric Injection Study

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Background/Purpose: Minimally invasive plate osteosynthesis (MIPO) of the femoral shaft, the distal femur, and periprosthetic fractures have achieved satisfactory clinical outcomes. The standard lateral approach is simple and carries the least risk for neurovascular injury. The percutaneous plate insertion on the medial side of the femur appears to be a dangerous procedure due to possible femoral artery injury. This study aims to determine the feasibility of applying MIPO of the femur via the medial approach, to observe the risk of injury to the femoral artery and to determine the anatomical relationship between the artery and the implant using computed tomography (CT) angiography.

Methods: A descriptive study of ten fresh cadavers (20 femurs) was done. Two separate incisions were made, creating a submuscular tunnel close to the medial side of the femur. An 11- or 13-hole LCP lateral proximal tibial plate (5.0) was inserted through the distal incision into the submuscular tunnel and was fixed to the proximal and distal femur with two screws on each side. A CT angiogram with 3-dimensional (3D) reconstruction was made to determine the distance from and location of the plate relative to the femoral artery. Finally, both incisions were connected and surgical dissection was done to identify the structures at risk with this approach.

Results: No disruptions of superficial or deep femoral arteries were found. The closest distances from the superficial femoral artery and deep femoral artery to the plate were 8.3 to 27.2 mm. (average 16.3 mm; 99% confidence interval [CI]: 12.7-19.9) at the level 3 and 4.5 to 20.0 mm (average 8.6 mm; 99% CI: 6.4-10.9) at the level 2 in the proximal part of femur, respectively. The location where the superficial femoral artery crossed the anterior cortex of the femur in the sagittal plane was 9.7% to 36.0% of the femoral length (average 20.1%; 99% CI: 15.0%-25.3%) and the posterior cortex of the femur was 24.7% to 55.3% of the femoral length (average 40.8%; 99% CI: 35.0%-46.7%). The location where the deep femoral artery crossed the anterior cortex of the femur in the sagittal plane was 7.9% to 25.3% of the femoral length (average 13.4%; 99% CI: 10.6%-16.3%) and where it crossed the posterior cortex of the femur was 21.7% to 39.4% of the femoral length (average 31.2%; 99% CI: 27.1%-33.3%). The only structure potentially at risk was the descending branch of lateral femoral circumflex artery, which may be encountered in the proximal dissection.

Conclusion: MIPO of the femur via medial approach is a feasible option for treatment of femoral fractures when the lateral approach is otherwise contraindicated. The distal two-thirds of the femoral length measured from tip of the greater trochanter to the lateral joint line of the knee is safe for this approach.

See pages 47 - 108 for financial disclosure information.

Under Pressure: The Utility of Splitting Fiberglass Casts

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Purpose: Univalving fiberglass casts after fracture manipulation or extremity surgery is commonly performed to reduce the risk of developing compartment syndrome. Previous experiments have demonstrated that univalving decreases intracompartmental pressures, but also alters cast mechanical properties, increasing risk for loss of fracture reduction. The purpose of this study was to correlate cast spacer width within a univalved cast as it relates to decreasing intracompartmental pressure.

Methods: 1-L saline bags with 200 to 250 mL removed were covered with 2-inch stockinette, Webril (50% overlap), and one roll of 3-inch fiberglass tape extending to the bag ends. Bags were connected to the arterial pressure line monitor. Resting pressure within each bag was recorded, then a water column was added to simulate two groups (n = 5 each) of clinical compartment syndrome (CS): Low Pressure CS (LPCS, range 28-31 mm Hg) and High Pressure CS (HPCS, range 64-68 mm Hg). After the designated pressure was reached, the fiberglass was cut with an oscillating cast saw, leaving the stockinette and Webril intact. Cast spacers were inserted into the univalve and taped into place at position #1 (3 mm wide), #2 (6 mm), #3 (9 mm), and #4 (12 mm). Pressure was recorded after the fiberglass was cut and following each spacer placement.

Results: In LPCS and HPCS groups, after univalve and placement of spacer position #1, pressure dropped by a mean 52% and 57%, respectively. Spacer #2, however, decreased the pressure by a mean 78% and 80%, respectively. Both spacer sizes significantly decreased the underlying pressure in both groups. Spacers #3 and #4 progressively reduced pressure to the pre-CS state within the cast, but not statistically significantly more than the previous spacer widths.

Conclusion: Our experimental model best replicates the iatrogenic elevation in the interstitial compartment pressure due to a rigid cast diameter, and not necessarily a self-sustained true compartment syndrome. Increasing the spread of a univalved cast to 9 mm of the initial cast diameter will reduce pressure to a pre-CS pressure; however, a spread of only 6 mm can effectively reduce the pressure to less than 30 mm Hg depending on the initial elevated intracompartmental pressure being observed. Although the utility of splitting a fiberglass cast has been previously demonstrated, we present evidence that highlights the benefit of spacing the split by at least 6 to 9 mm.

Targeted Stimulation of Retinoic Acid Receptor Signaling Mitigates the Formation of Heterotopic Ossification Formation in an Established Blast-Related Traumatic Injury Model

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PAPER ABSTRACTS

Background/Purpose: Heterotopic ossification (HO), which is the abnormal development of bone in nonosseous tissue, has been shown to be prevalent in 65% of combat wounds. Complications can be devastating, including skin ulceration, pain management crises, and prosthetic wear intolerance, all of which deteriorate rehabilitation and often lead to additional surgeries that can be wrought with complications. Furthermore, commonly used civilian prophylactic measures are generally contraindicated in the setting of combat and blast-induced trauma. Recently, our group has developed a traumatic small animal model that incorporates a combination of critical physiologic injury patterns sustained by combat casualties including blast exposure, extremity fracture, quadriceps crush injury followed by limb amputation through the zone of injury, and contamination of the myodesis with a combat wound isolate of methicillin-resistant Staphylococcus aureus (MRSA). Using this model we histologically characterized the timing of chondrogenesis to begin at about 10 days following injury. Knowing the proper timing of prophylactic administration, we now have a well-characterized model of HO whereby the efficacy of prophylactic therapeutics can be rigorously evaluated in a clinically relevant animal model. One such candidate drug retinoic acid receptor gamma (RAR-γ) agonist has been shown to mitigate a bone morphogenetic protein (BMP)-2-induced ectopic endochondral bone formation and inhibit cartilage vascularization in a non-trauma injury model in mice. Expanding on these findings, we sought to evaluate the efficacy and applicability of RAR-γ agonist in attenuating ectopic bone formation in our blast-trauma model.

Methods: We exposed 72 adult male Sprague-Dawley rats to 120 ± 7 kPa blast overpressure, followed by femur fracture, quadriceps crush injury, transfemoral amputation through the zone of injury, and bacterial inoculation with MRSA. Rats were either started on enteral gavage administration of RAR-γ agonist (1 μg/g of Palovarotene [Roche Pharmaceuticals] every other day for 14 days) or corn oil/DMSO (vehicle control) beginning on either postoperative day (POD) 1 or 5. Rats were monitored for 12 weeks for evidence of wound dehiscence and ectopic bone formation using micro computed tomography (CT) imaging to quantitate ectopic bone volume.

Results: Vehicle control-treated rats infected with MRSA gavaged on POD 1 and POD 5 had a mean ectopic bone volume of 42.8 ± 10.4 mm3 and 38.9 ± 8.5 mm3 respectively, compared to rats that received RAR-γ agonist on POD 1 (15.6 ± 4.1 mm3; P = 0.04) and POD 5 (20.7 ± 7.4 mm3; P =.09). The statistically significant attenuation of ectopic bone in rats adminis-

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tered with RAR-γ agonist beginning at our earliest time point (POD 1) correlates with our early histologic findings in which mature chondrocytes and vascularized hyaline cartilage appear by 10 to 14 days postinjury.

Conclusion: Given our early findings, RAR-γ agonist administered shortly following trauma may act to preclude the proliferation and further differentiation of chondrocytes during early endochondral ossification. This intervention may therefore represent a promising prophylactic therapy against ectopic bone formation. To our knowledge, this is the first study to demonstrate the applicability of a drug that can mitigate the formation of ectopic bone in a trauma-induced injury model without interfering with wound healing reparative processes.

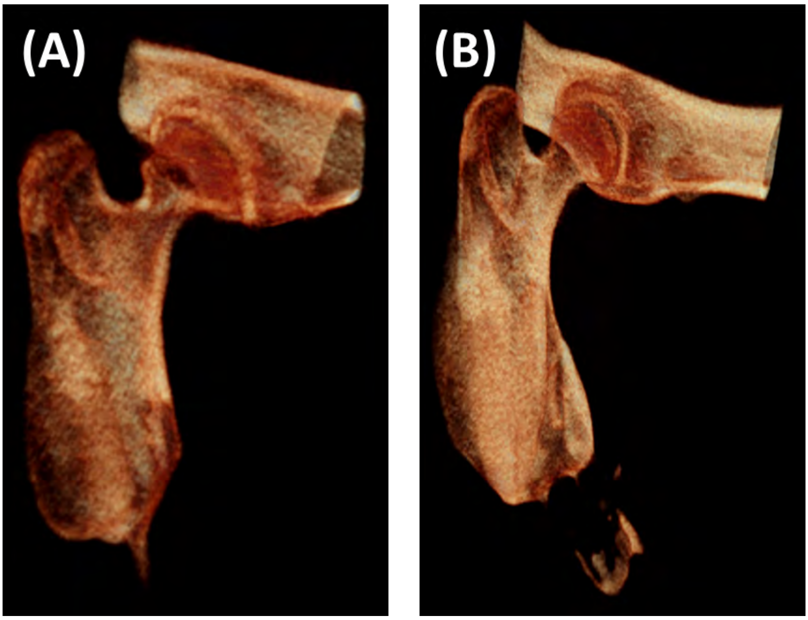

Figure 1. shows a 3D reconstruction of a 12-week post-injury MicroCT of a trauma-induced rat model infected with MRSA that was gavaged with (a) RAR-γ on POD1 (b) corn oil/DMSO beginning on POD1.

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.

Transforming Growth Factor-ß2 Gene Expression Early May Be Predictive of the Severity of Future Development of Heterotopic Ossification

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Background/Purpose: Heterotopic ossification (HO) remains a significant problem for wounded warriors. As many as 60% of extremity injuries resulting from high energy blasts will result in HO formation. HO may result in skin breakdown, which can complicate prosthetic fitting and limit joint range of motion. Although there have been many studies into the etiology of HO formation, there is still no current way of determining which patients will develop significant HO and which patients will not. In this regard, not all patients that develop HO will have symptomatic HO that requires reoperation. The purpose of this study was to correlate severity of HO formation with gene expression levels within the traumatized tissue early after the sustained injury.

Methods: We retrospectively reviewed 175 patients who had tissue collected during surgical debridements following combat injury. Patients were identified who positively developed HO with adequate radiographic evidence between 2 and 9 months postinjury. Patients were excluded if tissue samples were not obtained within 2 weeks of injury. Additionally, patients were excluded if the tissue sample was not adequate to perform RNA isolation. The included patients had their HO graded and were stratified into mild, moderate, or severe HO. Real time quantitative polymerase chain reaction (qPCR) was used to identify significant changes in gene expression between the groups.

Results: We identified 13 patients who meet the criteria for inclusion. All patients were male with an average age of 28 years (range, 23-39). Tissue was collected on average 10 days from injury (range, 5-16 days). All patients were injured as a result of IED (improvised explosive device) blast. Three patients were identified as having transtibial amputations, three had open femur fractures, and seven patients had transfemoral amputations. Following stratification of HO severity, four patients were identified as severe HO, four as moderate, and five as mild HO. Several genes demonstrated upregulation from mild to severe HO. Patients classified as moderate or severe HO had significant upregulation of collagen 3A1 (COL3A1) and β2 microglobulin expression compared to those with mild HO. However, the difference in collagen 3α1 and β2 microglobulin expression was not statistically significant when comparing severe to moderate HO. Transforming growth factor beta-2 (TGFβ-2), however, demonstrated over a twentyfold upregulation in mild compared to moderate HO and over a sixtyfold upregulation in mild to severe, which correlated to a threefold upregulation from moderate to severe HO, which was a statistically significant difference in gene expression. TGFβ2 was the only gene expressed that demonstrated a linear increase between the various grades of HO severity, and was also the only gene that demonstrated a statistical significant difference when comparing the moderate to severe HO formers.

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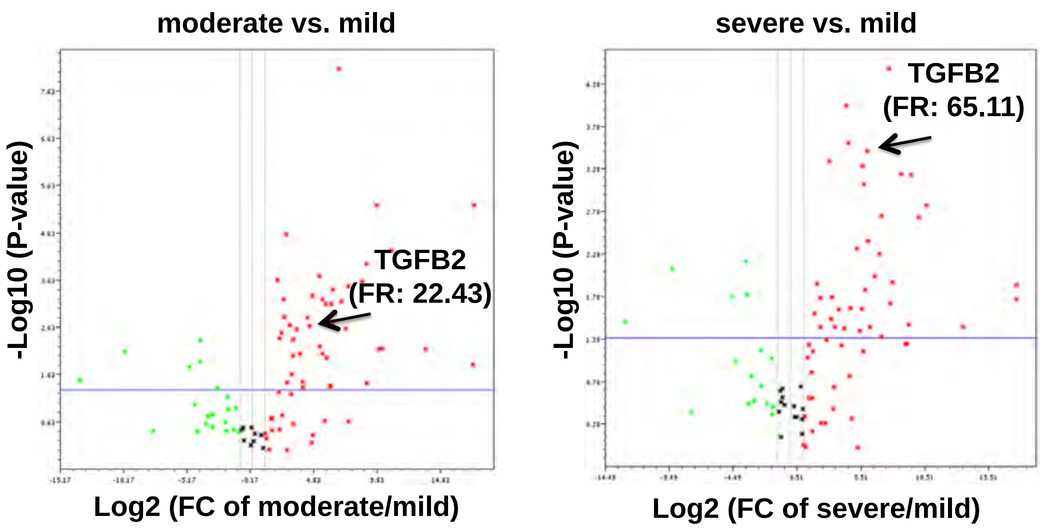
Conclusion: The ability to predict which patients will develop severe HO compared to those that will develop mild would allow clinicians to counsel patients about the potential need for future reoperation and provide them with closer follow-up. TGFβ-2 expression as a marker may have predictive value for severity of later HO development. This known mediator of fibrotic tissue development is increasingly upregulated in the patient developing mild, moderate, or severe HO. There were other genes expressed, such as COL3A1, which demonstrated a significant upregulation in the moderate and severe groups when compared to mild HO formers; however, none of these showed the linear progression from moderate to severe demonstrated by TGFβ-2. Furthermore, these markers may serve to identify patients in need of HO prophylaxis, as they may be at a higher risk of developing moderate to severe HO, which could necessitate additional operations to address symptomatic HO or other complications typically encountered with increased severity of HO.

Fig 1: Volcano plot demonstrating fold increase in TGFB2 expression in moderate and severe compared to mild HO group



Repetitive Reduction Leads to Significant Elevated IL-6 Levels in Femoral Fractures: A Quantitative Analysis of a Robot-Assisted Reduction Process in a Rat Model

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Purpose: The field of robot-assisted fracture reduction has been developed by several research groups over more than one decade by now. The main goals are to increase the fracture reduction accuracy by reaching anatomically correct bone alignments, and also to relieve the surgeon from x-ray exposure as well as from the exhausting task of fracture manipulation against strong soft tissues, especially in the femur. Robotized procedures, with their precise and well-controlled motions, have the potential to achieve a more gentle and soft-tissue-preserving operation outcome. However, the influence of different reduction paths to the patients' physiology is not yet fully known. The aim of our study was to compare in an in vivo rat model the impact of a robot-assisted direct reduction path to the impact of an artificially prolonged reduction path by measuring the cytokine responses.

Methods: We developed a robotic testing environment for femur fracture reduction in a rat model. The developed system uses an industrial robot, a Stäubli RX 90, with its standard robot control unit, a CS7B. The robot is controlled from a Windows PC with self-made control software written in C++. The direct reduction path used for our tests consisted of a distraction of 2 mm followed by a vertical displacement of first 10 mm up and then 20 mm down. Finally, the bone is moved back to the starting position for an anatomically correct reconstruction of the fracture. The prolonged reduction path consisted of the same steps, but these steps were repeated 10 times. For the study, 36 male rats were divided equally and randomly assigned into three groups (A, B, and C). A reference blood sample was collected from all rats 1 hour before operation procedure started. Afterwards all rats were anesthetized and an external fixator was attached to the left femur. Next, an osteotomy of the femur was performed between the two inner pins of the external fixator using a Gigli wire. Three days later the robot was attached in rats of the group A and B to the distal femur part and a mechanical holding device was attached to the proximal femur part. Group A received a fracture reduction on a direct path, whereas group B received the prolonged reduction path using 10 repetitions. The third group (C) was the control group. In this group, the external fixator was attached to the femur, but no reduction was performed. 0, 6, 24, and 48 hours, after the reduction process blood samples were collected. The following markers where analyzed via ELISA (enzyme-linked immunosorbent assay) or cytometric bead assay: interleukin (IL)-1, IL-4, IL-6, IL-8, IL-10, IL-17, MCP (monocyte chemotactic protein)-1, interferon gamma, and TNF (tumor necrosis factor) alpha. Statistical significance was set at $P < 0.05$. Furthermore, muscle biopsies in the area of the osteotomy were collected 48 hours after the reduction process for histologic analyses.

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Results: Analysis of the cytokines showed that the pr-inflammatory cytokine IL-6 of group B (prolonged reduction) had a significant rise 6 hours after reduction compared to the control group. IL-6 further showed markedly elevated levels 6 and 24 hours after operation in group B compared to the direct reduction of group A. On the anti-inflammatory side, IL-10 showed a significant decrease in group B 6 and 48 hours after reduction compared to group A or C. Furthermore, the muscle biopsies showed a significant increased soft-tissue damage in group B compared to group A.

Conclusion: It could be shown that the developed robotic test bench is suitable for comparing the physiologic impact of different fracture reduction procedures utilizing cytokine measuring in a rat model. Different reduction procedures produce different responses in the measured cytokine markers. In particular, it was possible to distinguish between a direct and a prolonged reduction procedure. The response of IL-6 was considerably higher in the prolonged procedures 6 and 24 hours after operation compared to the performed direct reductions. Therefore, it can be concluded that a direct and gentle reduction procedure is preferable over a prolonged and straining reduction and might potentially support the postoperative healing process of the patient.

∆ Carbon Monoxide Releasing Molecule-3 (CORM-3) Protects the Skeletal Muscle in a Porcine Model of Compartment Syndrome

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Purpose: Acute limb compartment syndrome (CS), a devastating complication of musculoskeletal trauma, results in muscle necrosis and cell death. Fasciotomy, to decompress all affected compartments, remains the only gold standard treatment, but must be performed within a 6- to 8-hour surgical window. Recently, carbon monoxide (CO), liberated from the carbon monoxide releasing molecule-3 (CORM-3), has been shown to protect microvascular perfusion and reduce inflammation in a rat model of CS. The purpose of this study was to test the effect of CORM-3 in a preclinical setting, using a large animal model of CS (pig). The ultimate goal is the development of a rational pharmacologic adjunctive treatment for CS, capable of prolonging the surgical window, and reduce the morbidity and disability in patients.

Methods: Pigs were anesthetized with isoflurane, intubated, and had a femoral artery line put in for invasive cardiovascular monitoring/blood sampling. They underwent 6 hours of intracompartment pressure (ICP) elevation by infusing saline enriched with bovine serum albumin (0.4 g/L) into the anterior compartment of the right hind limb. CORM-3 (or its inactive counterpart, iCORM-3) was administered systemically (2 mg/kg, IV) at fasciotomy, and the muscle was allowed to reperfuse for 3 hours. Subseq[ently, tissue perfusion (orthogonal polarized spectral imaging), cellular injury (ethidium bromide [EB]/bisbenzimide [BB] staining ratio) and apoptosis (FLIVO/BB staining ratio) were assessed in the skeletal muscle of all pigs. In parallel, systemic polymorphonuclear leukocyte (PMN) activation (L-012 assay) was assessed at various time points during CS and reperfusion in all animals.

Results: Elevation of hind limb ICP for 6 hours resulted in significant microvascular perfusion deficits (44 ± 1% continuously perfused capillaries in CS vs 76 ± 4% in sham, P <0.001; 39 ± 3% nonperfused capillaries in CS vs 13 ± 2% in sham, P <0.001), increased tissue injury (EB/BB of 0.31 ± 0.07 in CS vs 0.17 ± 0.03 in sham, P <0.05), apoptosis (FLIVO/BB of 0.26 ± 0.06 in CS vs 0.13 ± 0.03 in sham, P <0.05), and activation of leukocytes in the systemic circulation (14.7 relative luminescence units/106 PMNs in CS vs 1.0 ± 0.1 in baseline, P <0.001). Systemic application of CORM-3 (but not iCORM-3) at fasciotomy was able to increase the number of continuously perfused capillaries (68 ± 3%, P <0.001), decrease the number of nonperfused capillaries (25 ± 3%, P <0.05), diminish tissue injury (EB/BB of 0.13 ± 0.04, P <0.05), apoptosis (FLIVO/BB of 0.12 ± 0.03, P <0.05), and completely block the systemic leukocyte activation (3.9 ± 0.3 relative luminescence units/106 PMNs, P <0.001).

Conclusion: Administration of CORM-3 at fasciotomy offered protection against CS-induced microvascular perfusion deficit, tissue injury, and systemic leukocyte activation. The data suggest the potential therapeutic application of CORM-3 to patients at risk of developing CS.

∆ OTA Grant

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Δ The Effect of Iron Chelators on Bioceramic Bone-Graft Remodeling

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Purpose: The clinical success of bone-graft substitutes for posttraumatic reconstructive procedures relies on the rapid vascularization of the construct while temporizing graft resorption to maintain structure and strength during bone ingrowth. Local delivery of the widely available iron chelator, deferoxamine (DFO) has recently been shown to augment both angiogenesis and osteogenesis in fracture models through activation of the hypoxia-inducible factor (HIF) signaling pathway. Hypoxic conditions are also known to induce osteoclast differentiation and resorptive function through HIF activation: however, mimicking this effect with iron chelators has interestingly shown contradicting in vitro results. We aimed to determine the effect of the local delivery of DFO on new bone growth in a rabbit ulnar defect bridged by anatomical 3-dimensional (3D)-printed monetite ($CaHPO4$) bone-graft substitutes. Secondly we aimed to accurately quantify the effect of iron chelator delivery on osteoclast mediated graft resorption using a monetite graft cranial onlay model.

Methods: Microporous 10-mm monetite grafts were 3D-printed to anatomically match a rabbit midshaft ulna. Cylindrical grafts (9-mm diameter, 4-mm thick) were prepared for the cranial model. In six rabbits, grafts were inserted into bilateral 10-mm middiaphyseal ulna defects. Starting on day 4 postoperatively, 600 μL of DFO (200 μM) was injected into one graft of each rabbit every 48 hours for 6 doses. The contralateral limb received saline injections. In 10 rabbits, two circular grafts were fixed subperiosteally onto the cranium. Four of these rabbits had DFO injected in a similar fashion into both grafts and four rabbits were given saline. To verify if the results could be replicated using another chelator, two rabbits were injected with 1,10-phenanthroline. At 8 weeks, micro computed tomography (CT) and histology were used to assess new bone growth and graft resorption. Additionally, histologic sections of the cranial grafts were TRAP (tartrate-resistant acid phosphatase)-stained to assess for osteoclast density at the bone-graft interface.

Results: Ulnar model: At 8 weeks postimplantation, micro CT analysis demonstrated a significant increase in new bone growth in the DFO group compared to the saline group (bone volume/tissue volume 19.50% vs 13.65% [P = 0.042], Fig. 1). Histologic analysis of coronal sections showed increased bone within the osteotomy gap, more bone integrated at the graft surface, as well a more matured soft-tissue callus in the DFO group. Cranial model: Micro CT and histologic analysis showed a markedly decreased resorptive front in the DFO and PHT group as compared to saline controls. TRAP stain quantification showed a 3-fold significant decrease in osteoclast density in the chelation groups compared to controls.

Conclusion: DFO significantly increased bone formation in a long bone defect bridged by a bioresorbable bone graft substitute. The cranial onlay model exposes the grafts to a more static environment whereby cell mediated resorption can be tracked from a single front. Local delivery of chelators reduced graft resorption and osteoclast numbers at the bone graft interface in this model. This study proposes a second mechanism by which iron chelators

Δ OTA Grant

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may function as bone anabolic agents; in addition to HIF activators, they may also reduce osteoclast mediated resorption by additional mechanisms.

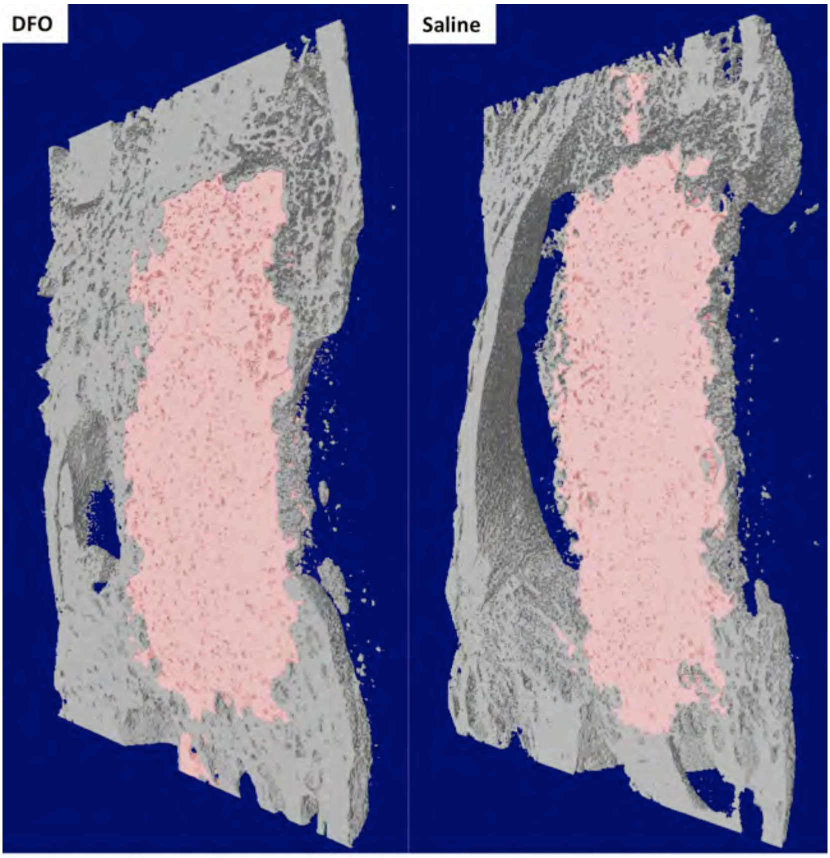

Figure 1: Representative 3D coronal cuts of the osteotomy site. Grey represents new bone and pink represents the remaining graft material.

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ORTHOPAEDIC
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A Prospective, Randomized Controlled Trial Comparing the Fibular Nail versus Standard ORIF for Fixation of Ankle Fractures in Patients Under 65 Years of Age

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Purpose: The technique of open reduction and internal fixation (ORIF) of ankle fractures with plates and screws has not changed substantially since the 1960s. Three principal complications are associated with this type of surgery. First, wound dehiscence and infection, with published rates of up to 30%, and higher rates in patients with diabetes and neuropathy. Second, there is a risk of construct failure, particularly in osteoporotic bone. Third, the scar or prominent hardware may cause later irritation and require further surgery. We have previously reported that fibular nailing in the elderly is associated with a significantly reduced complication rate and better cost-effectiveness when compared to ORIF. We hypothesized that fibular nailing in younger patients would result in comparable outcomes, with a reduced rate of wound and hardware problems.

Methods: 100 patients aged 18 to 64 years with unstable ankle fractures requiring fixation were randomized to undergo fibular nailing or standard stabilization using AO techniques. Immediate weight-bearing in cast was permitted. Outcome measures were assessed over 2 years postoperatively and included: the accuracy of reduction, development of wound complications or radiographic arthritis, range of movement, Olerud and Molander score (OMS), and patient satisfaction. The mean age was 44 years (range, 18-64) and 56 patients were women. 25% of patients were smokers, three were diabetic, and 35% had some form of comorbidity, most commonly hypertension or ischemic heart disease. 27 injuries occurred during sport and two after an assault; the remainder occurred after a simple fall from a standing height.

Results: Patient satisfaction with the surgical scar was higher after fibular nailing (visual analog scale mean 0.75; range, 0-5) than for ORIF (mean 1.5; range, 0-7). Superficial wound infections that resolved with oral antibiotics occurred in two patients in each group. Six patients requested removal of the nail, and five further requested removal of the locking screws. In the ORIF group, nine patients requested plate and screw removal. Patient-reported outcome scores were comparable for the two groups. Two failures of fixation occurred in the fibular nail group: one in a patient with neuropathy, and one in a patient who developed a postoperative pulmonary embolism and failed to attend follow-up. One failure of fixation occurred in the ORIF group. All other patients went on to an anatomic union without complication.

Conclusion: The fibular nail allows accurate reduction and secure fixation of ankle fractures, with comparable radiographic and patient-reported outcome at 2 years, and a greater patient satisfaction with the appearance of the surgical scars. Neuropathy should be a contraindication to early weight-bearing.

An Equivalence Randomized Controlled Trial Comparing Close Contact Casting (CCC) with Internal Fixation Surgery for Unstable Malleolar Fractures in Patients Over 60 Years

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Purpose: The decision to treat an unstable malleolar fracture by surgery in older adults is complicated by comorbidities, increased risk of infection, surgical wound problems, and inadequate fixation due to poor bone quality. Close contact casting (CCC), is a novel casting technique that may offer an alternative to open reduction and internal fixation (ORIF). We aimed to determine the clinical and cost-effectiveness of CCC compared to ORIF in adults aged over 60 years.

Methods: This was a pragmatic, multicenter, equivalence randomized controlled trial incorporating health economic evaluation. Recruitment was from 24 hospitals. Exclusions were: serious limb or concomitant disease or substantial cognitive impairment. Participants were randomized using computer allocation via a 24-hour telephone service. The primary outcome, Olerud and Molander Ankle Score (OMAS), was collected at 6 months by blinded assessors. A qualitative patient-experience study was embedded.

Results: We randomized 620 participants (309 ORIF, 311 CCC); mean age 71 years (74% female). Follow-up assessments at 6 months were completed by 593/620 (96%) participants. Per protocol analysis showed CCC resulted in equivalent functional outcome compared to ORIF (OMAS mean difference -0.65 [95% CI (confidence interval): -3.98, 2.68]); equivalence margin preset at ±6 points. Intention-to-treat analysis demonstrated the same equivalence. There were no differences in secondary outcomes of quality of life (mental and physical), ankle range, pain, mobility, and patient satisfaction. Complications occurred in both groups; commonest for CCC group were loss of reduction and conversion to ORIF, and for ORIF group were wound breakdown and surgery for wound/implant problems. CCC showed mean cost savings to the universal health care service (mean difference -$968 [95% CI -2,089, 114]) and society (mean difference -$1,026 [95%CI: -2,782, 806]). Over common willingness-to-pay thresholds, the probability that CCC was cost-effective was very high (>95%). The experiences of the treatments were similar as both groups endured the impact of ankle fracture and uncertainty regarding future function and the necessity for further interventions.

Conclusion: CCC provides a clinically equivalent outcome to ORIF with a cost reduction to the universal health care service and society. Identifying a nonsurgical treatment evidenced to deliver the same patient outcome must now produce a shift in the approach of surgeons in advising older patients with unstable malleolar fractures.

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Proximal Fracture of the Humerus: Evaluation by Randomization (ProFHER) Trial

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Background/Purpose: Proximal humeral fractures are common injuries, accounting for 5% to 6% of all adult fractures, with an estimated 706,000 having occurred worldwide in 2000. Around half (51%) of these fractures are displaced, the majority of which involve the surgical neck (40% of all fractures). Cochrane review has found, at each update, insufficient evidence from randomized controlled trials to inform practice, including whether surgical intervention, even for specific fracture types, produces consistently better outcomes, and well-designed trials are needed to answer this question. The ProFHER trial was designed to evaluate the clinical and cost-effectiveness of surgical versus nonsurgical treatment for adults with displaced fractures of the proximal humerus involving the surgical neck.

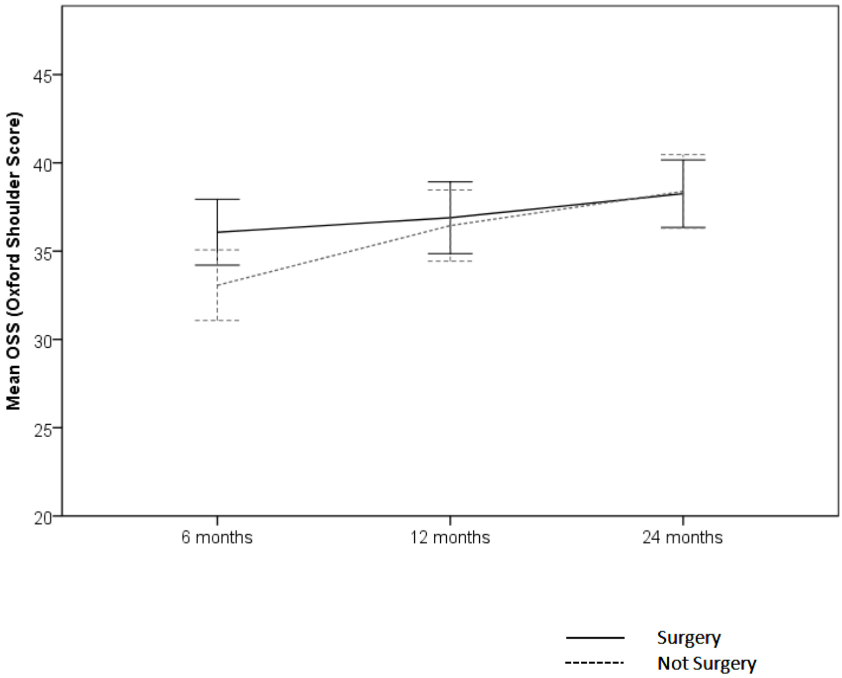
Methods: The ProFHER trial is a pragmatic parallel group multicenter randomized controlled trial, with an economic evaluation. Recruitment was undertaken in the orthopaedic trauma departments of 33 hospitals from September 2008 to April 2011. Surgeons used surgical techniques of fracture fixation or humeral head replacement with which they were experienced. Initial nonsurgical treatment was sling immobilization. Rehabilitation was standardized and included outpatient and community based rehabilitation. The primary outcome was the Oxford Shoulder Score (OSS; scale 0 to 48, higher scores indicating better outcome) assessed over 6, 12, and 24 months. The trial was powered to detect a clinically important difference of 5 OSS points. Secondary outcomes were the Short-Form 12, EuroQol-5D-3L, complications, subsequent therapy, and mortality.

Results: The 250 participants (125 randomized to each group), aged 16 years or older, presented within 3 weeks of sustaining a displaced fracture of the proximal humerus that involved the surgical neck. Of these, 215 participants (106 surgery, 109 not surgery) completed follow-up. There was no significant between-group difference in OSS over the 2-year period (0.75 points in favor of surgery, 95% confidence interval [CI] -1.33 to 2.84; P = 0.48), nor at individual time points. We found no statistically significant between-group differences in secondary outcomes, including surgical or fracture-related complications (30 vs 23 patients) and secondary surgery to shoulder (11 each group). Surgery cost significantly more over 2 years.

Conclusion: Current surgical practice does not result in a better patient-reported outcome for most adults with displaced proximal humeral fractures involving the surgical neck, and is not cost-effective in this setting.

PAPER ABSTRACTS

Comparison of OSS by treatment groups:



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Participant Flow:

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.

A Multicenter RCT Comparing the InterTAN Device Versus the Sliding Hip Screw in the Treatment of Geriatric Hip Fractures: Results Depend on Preinjury Functional Level

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Background/Purpose: The benefit of intramedullary devices for the treatment of intertrochanteric hip fractures in the elderly is unknown. This may be related to the functional capacity of patients who sustain hip fractures, as incremental improvements in function may be difficult to appreciate. The InterTAN (IT) device was designed to allow earlier mobilization for patients with intertrochanteric fractures. Our objective was to determine whether the mechanical benefits of this device would translate into improved function for elderly patients with hip fractures, compared to a conventional sliding hip screw (SHS).

Methods: 249 patients aged 55 years or older were prospectively enrolled in an REB-approved multicenter study, and computer randomized to either IT (n = 123) or SHS (n = 126). Patients were followed for 12 months. The validated primary outcome measures were the Functional Independence Measure (FIM), to measure function, and the Timed Up and Go test (TUG), to measure motor performance. Secondary outcome measures included femoral shortening, complication,s and mortality. A preinjury FIM was measured by retrospective recall, and all outcomes assessed at discharge, 6 weeks, 3 and 6 months, and 1 year postoperative. 100 patients per group with complete data were required to have 80% power to detect differences in the FIM score of 7.8 points or greater using a two-sided ANOVA (analysis of variance) with a type I error rate of 5%.

Results: Fractures included 43 31A-1, and 199 31A-2 fractures. Age, sex, body mass index (BMI), living status, and comorbidities were similar between groups. The recalled preinjury FIM scores were similar between the SHS and IT groups and followed a similar pattern of recovery after discharge. The average FIM motor subscale at 12 months was 4.5 ± 1.1 points lower than preinjury. The proportion of patients able to complete the TUG, as well as the time, was similar between the SHS and IT groups at each time interval. Fewer patients who received an IT (17.2%) had limb shortening greater than 2.5 cm compared to those who received a SHS (42.9%) (P <0.001). There were no differences in secondary outcomes. To determine

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the role of preinjury function, we analyzed the subgroup of patients with the ability to walk 150 feet independently preinjury (FIM walk score of 7) and a 31A-2 fracture. 70 patients met these criteria (36 SHS, 34 IT). Patients treated with SHS followed a bimodal distribution of outcomes, associated with radiographic shortening. In this subgroup, patients treated with SHS with greater than 2.5 cm of shortening demonstrated poorer FIM and TUG scores compared to patients treated with SHS without shortening, or patients treated with an IT.

Conclusion: Patients with intertrochanteric proximal femur fractures can expect similar results whether treated with an intramedullary or extramedullary device. However, our study demonstrates an advantage to the IT device in patients with superior functional capacity prior to their unstable intertrochanteric hip fracture. In these patients, treatment with a SHS complicated by shortening resulted in worse outcome. These results may help orthopaedic surgeons decide which surgical implant is most appropriate for individual patients in the treatment of intertrochanteric hip fractures.

The Suprapatellar Variant of the Semi-Extended Surgical Approach Improves Intramedullary Nail Position Compared with the Conventional Medial Parapatellar Surgical Approach

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Background/Purpose: Proximal third tibial shaft fractures remain a challenge to treat with intramedullary nails (IMNs) due to the risk of creating malunion by using the conventional medial parapatellar (CMPP) surgical approach. Although the lateral parapatellar approach reduces the incidence of valgus malunion, recurvatum is still a concern. To reduce malalignment, Tornetta and Collins postulated the semi-extended (SE) approach for IMN insertion since placing the knee in approximately 15° of flexion usually results in good proximal fracture alignment. Their original article described using an open approach involving reflection of the patella, but more recently, a less invasive modification of the SE approach that permits IMN insertion using a suprapatellar incision (SPSE) has been developed. We hypothesized that the SPSE surgical approach permits more accurate placement of the guidewire (GW) and the IMN compared with the CMPP approach.

Methods: A multicenter randomized controlled trial (RCT) was undertaken comparing the CMPP approach with the SPSE approach. 94 patients with isolated extra-articular tibial shaft fractures were recruited. Standardized AP and lateral perioperative and early postoperative radiographs were used to assess (1) GW and (2) IMN alignment with respect to the long axes of the tibia, (3) the starting point of the GW on the proximal tibia in both planes, and (4) the final position of the proximal end of the nail in both planes within the proximal tibia. One experienced assessor, blinded to the treatments, undertook all measurements. Statistical analysis was undertaken using a Mann-Whitney U test with significance set at $P < 0.05$.

Results: Overall alignment of (1) the GW and (2) the IMN with respect to the long axes of the tibia, (3) the GW starting point, and (4) the final position of the IMN in the proximal tibia were all improved by using the SPSE approach, although not all were statistically significant. The notable statistically significant results relate mainly to IMN placement and are as follows: overall IMN alignment in the coronal plane, $P = 0.0061$; overall IMN alignment in the sagittal plane, $P = 0.0032$; and final position of the proximal end of the IMN within the proximal tibia in the sagittal plane, $P = 0.0294$--favoring the SPSE approach.

Conclusion: The results of this multicenter RCT confirms that GW and IMN position is improved when the SPSE approach is used compared with the CMPP approach. However, the most interesting findings relate to (1) IMN alignment with respect to the long axes of the tibia and (2) the final position of the IMN in the proximal tibia in the sagittal plane. In essence, while using a CMPP approach to insert an IMN, the initially acceptable GW position is lost following reaming of the canal. This presumably results from eccentric reaming though using protective sleeves that are displaced by pressure from the patella and the patellar tendon. This problem is not observed using the SPSE approach and infers that the SPSE surgical approach is the preferred one for treating proximal third and segmental tibial fractures where the potential for malunion is of great concern.

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Low-Intensity Pulsed Ultrasound in Acute Tibial Shaft Fractures Treated with IM Nails: The Results of the TRUST Trial

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Background/Purpose: Tibial shaft fractures are one of the most common fractures treated by orthopaedic trauma surgeons and results of large trials have shown continued disability at 1 year. Additionally, functional outcome has been correlated with radiographic progression to union. The plateau period for functional outcome is between 6 months and 1 year for patients with fractures that heal without secondary intervention. Decreasing the time to union would likely hasten the recovery of patients. The use of low-intensity pulsed ultrasound (LIPUS) for acute tibial fractures has support in prior studies in animals and also in small series of tibial shaft fractures in adults. However, due to limitations of prior studies, the effect of LIPUS on promoting functional recovery for acute tibial fractures treated with IM (intramedullary) nailing remains uncertain. The purposes of this study were to evaluate the use of LIPUS on validated functional outcomes of patients with acute tibial fractures treated with IM nails and to evaluate healing using the RUST method (Radiographic Union Scale for Tibial fractures).

Methods: This trial was designed as a multicenter (43 centers) randomized, blinded, placebo/treatment controlled evaluation of the effects of LIPUS on validated functional outcomes (Short Form [SF]-36 PCS [Physical Component Summary] and HUI [Health Utilities Index]-III) and healing (RUST score). All patients over 18 years old with an acute closed or open fracture of the tibial diaphysis who were to be treated with intramedullary nailing were eligible. Fracture exclusion criteria included: soft-tissue damage precluding the use of the device, bilateral fractures, segmental fractures, and defects after open fracture of >75% of the circumference and longer than 1 cm. Patients were allocated to an active or sham LIPUS device through central randomization in a 1:1 ratio, stratified by fracture severity (ie, open vs closed). Patients used the device once daily after training. The device was set to an automated 20 minutes and recorded compliance. Outcomes were obtained at 6, 12, 18, 26, and 52 weeks. The study was powered for the minimum clinically significant difference in the SF-36 PCS using a repeated measures analysis at three levels (patient, center, and visit) at 500 patients assuming a 10% loss to follow-up. Time to adjudicated union was evaluated using a Cox proportional hazards regression model.

Results: 501 patients (156 F, 345 M, average age 38 years) with 114 open and 387 closed fractures were enrolled. The fracture patterns were: comminuted (132), transverse (114), spiral (177), and oblique (154). 125 were lost or withdrew consent, and 303 patients were followed for 1 year at which point the interim analysis met stopping rules and the study was concluded. The results are summarized in Table #1. There was no difference in time

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to union, with the hazard ratio = 1.06 (95% confidence interval [CI]: 0.85, 1.33), P = 0.594. The Kaplan-Meier curves for percentage not united for both groups in days from surgery are seen in Figure #1.

Conclusion: LIPUS does not result in improved functional outcomes or time to union in patients with tibial diaphyseal fractures treated with IM nails. Only the presence of an open fracture had a negative influence on outcomes.

Low Intensity Pulsed Ultrasound in Acute Tibial Shaft Fractures Treated with IM Nails: The Results of the TRUST Trial

Table 1: 3-Level Repeated Measures Analysis. N=2294 observations from 477 patients (p values)

	SF-36 PCS	HUI-III
Randomized Treatment	0.346	0.345
Time from surgery	<0.001	<0.001
Open vs closed fracture	0.008	<0.001
Treatment by time interaction	0.230	0.904
Open/closed by time interaction	0.629	0.965
Pre-injury score	<0.001	<0.001

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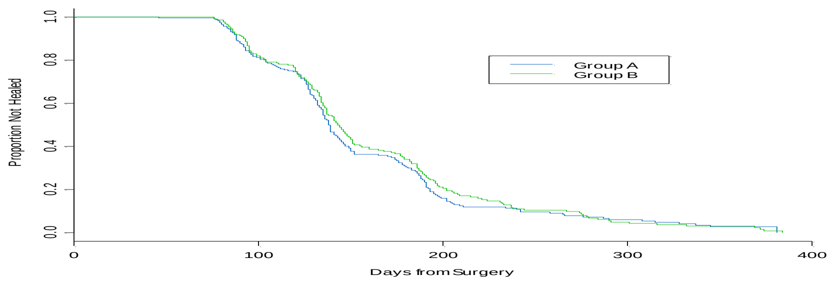
Figure #1



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A Multicenter, Blinded, Randomized Trial Comparing Soap Versus Saline Lavage in Patients with Open Fractures

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Background/Purpose: Open fractures can have devastating complications, including infections, wound healing problems, and failure of fracture healing, many of which necessitate subsequent operations. The initial management of open fractures mandates a thorough wound irrigation and debridement to remove contaminants. A lack of consensus regarding the optimal approach to irrigating open fracture wounds fueled the design and execution of the FLOW multinational randomized controlled trial (RCT). Using a 2 x 3 factorial design, FLOW investigated the effects of irrigation solutions (soap vs normal saline) and irrigation pressure (low vs high; gravity flow vs high; low vs gravity flow) on reoperation within one year among patients with open fractures. Here, we present the effect of the type of irrigating solution on reoperation rates.

Methods: The FLOW RCT included patients with operatively managed open fractures of the extremity randomized to one of the two open wound irrigation arms (castile soap and normal saline). The primary outcome was reoperation within 12 months to promote wound or bone healing, or to treat an infection. Secondary outcomes included patient function and quality of life measured by the Short Form-12 (SF-12) and the EuroQol-5D (EQ-5D) at 1, 2, and 6 weeks, and 3, 6, 9, and 12 months, as well as rates of nonoperatively managed infections, wound healing problems, and fracture healing problems within 12 months. Patients, outcome adjudicators, and data analysts were blinded. The primary analysis will utilize log-rank test and Kaplan-Meier survival curve to compare the main effects of irrigation solution on time to the first reoperation after the initial surgery.

Results: 2549 patients were enrolled into the FLOW trial over a 4-year period from 2009 to 2013 at 42 clinical sites in the United States, Canada, Australia, Norway, and India. The final patients completed their 12-month follow-up in the fall of 2014, and data analysis is currently underway. We will complete the analysis and draft papers presenting the primary and secondary outcome results for the irrigating solution comparison in early 2015. Our rationale for submitting the abstract prior to data analysis is to ensure that the OTA is the inaugural venue in which the results of this benchmark trial are presented.

Conclusion: The FLOW trial is the largest randomized trial conducted to date in the field of orthopaedic surgery, and represents a major international effort to identify a simple, effective, and easily applicable strategy for the management of open fracture wounds. The results will determine whether the use of soap solution, at pennies per application, can reduce the risk of reoperation, and will have potentially important clinical and economic implications, in particular to patients in low and middle income countries where disability from traumatic injuries is substantial.

Can Electromagnetic Navigation for Distal Locking of Intramedullary Nail Reduce Procedure Time and Radiation Exposure?

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PAPER ABSTRACTS

Background/Purpose: Distal locking screw insertion for intramedullary nails can lead to prolonged operation time, increased irradiation, and frustrations for those surgeons who treat tibial shaft fracture occasionally. Failure to insert distal locking screws can lead to malunion or nonunion. Electromagnetic navigation (E-navigation) was developed to provide surgeons with fast and easy technique for distal locking screw insertion. It provides 3-dimensional images and real time feedback of drill bit tip and locking holes location on the monitor without use of fluoroscopy. The purpose of this study was to compare the distal locking procedure time and intraoperative fluoroscopy exposure time for the two distal locking screw insertions using a conventional method (CM), and E-navigation. We hypothesized that the use of E-navigation would decrease the procedure time and fluoroscopy exposure time over all.

Methods: We conducted a multicenter randomized parallel group study at ten hospitals. Patients who underwent surgical fixation of tibia by intramedullary nail were recruited and randomized to one of two groups by method of distal locking: (1) CM such as free-hand technique or radiolucent drill technique and (2) E-navigation. The decision to use free-hand or radiolucent drill was according to surgeon's preference. Two distal locking screws insertion (SI) time starts at time of removing guide wire for nail and completion of two interlocking placement was recorded, and SI fluoroscopy time was also recorded. Statistical analysis was performed using the Tukey-Kramer method with significance set at a P value <0.05.

Results: From December 2011 to December 2014, 157 patients were recruited for the study. 79 patients were CM group (40 with free-hand technique, and 39 with radiolucent drill technique), and 78 were E-navigation group. SI time was 800 seconds in E-navigation, 1015.7 seconds in radiolucent drill, and 829.4 seconds in free-hand (Fig.1a). SI fluoroscopy time was 37.2 seconds in E-navigation, 289.2 seconds in radiolucent drill, and 173.5 seconds in free-hand (Fig.1b).

Discussion/Conclusion: There have been 5 publications about E-navigations used in distal locking procedure as far as we know. All but one concluded that use of E-navigations shortens the time of distal locking screw fixation time, but Maqungo et al reported that time to insert distal locking screws were not significant in both methods and concluded that the surgeons are well versed in the free-hand technique, that E-navigation was equivalent in speed. In our study SI time of E-navigation and free-hand also did not have significant difference. It might not be necessary to use E-navigation for experienced surgeons concerning speed,

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but all five articles and our study showed significant reduction in the radiation exposure. In our study, we were able to reduce about 80% of fluoroscopy time. That is a great advantage since radiolucent drill technique is the major technique used in our country. We believe E-navigation is a great option for quicker distal locking, and more in reducing the radiation exposure to patient and surgeons.

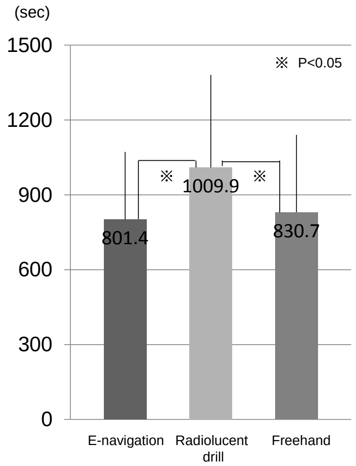

Fig. 1a Screw insertion time

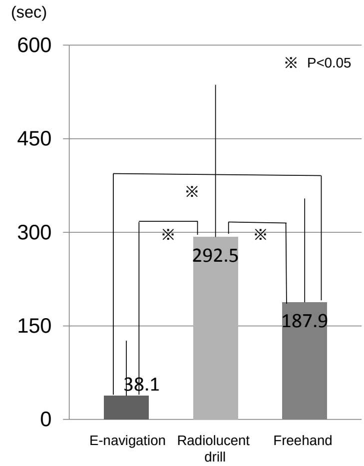

Fig. 1b Screw insertion fluoroscopy time

Suprapatellar Intramedullary Nail Technique Lowers Rate of Malalignment of Distal Tibia Fractures

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Purpose/Background: Distal tibia fractures are challenging to align anatomically with infrapatellar intramedullary nail (IMN) techniques with the knee in flexion. Vallier et al reported on radiographic outcomes following treatment with either IMN or plate fixation and found a 23% rate of malalignment in distal tibia fractures treated with an infrapatellar IMN. In a larger trial, Im and Tae identified an 11.7% incidence of angular deformity >5° in the infrapatellar IMN group. Suprapatellar IMN insertion enables the surgeon to maintain the leg in a semi-extended position, which eliminates the challenges associated with knee flexion of the limb required for instrumentation and fixation with infrapatellar IMN techniques. We hypothesize that use of the suprapatellar IMN technique results in lower rates of malalignment following surgical treatment of distal tibia fractures compared to infrapatellar IMN insertion.

Methods: A retrospective review of distal tibia fractures treated with an IMN from 2008 to 2014 at two Level-I trauma centers was completed. Demographic data for each patient were abstracted from chart review. Distal tibia fractures were graded according to the OTA classification scheme on injury radiographs. Patients were grouped into those who underwent either suprapatellar or infrapatellar IMN insertion in fractures located up to 5 cm from the tibial plafond. Anatomic alignment of the tibia was measured on postoperative radiographs on both the AP and lateral views. Acceptable radiographic alignment was defined as <5° in any plane. A trained reviewer not involved in direct care of the study groups graded each radiograph. Statistical analysis was completed using Pearson uncorrected chi-square test. $P < 0.05$ was considered statistically significant.

Results: 266 patients meeting all inclusion criteria were identified. 132 patients underwent suprapatellar IMN, and 134 underwent infrapatellar IMN. The two treatment groups were evenly matched with respect to age, gender, fracture grade, and presence of open fracture. Within the suprapatellar group, the fibula was intact, fixed, and remained fractured in 6 (4.5%), 22 (16.7%), and 104 (78.8%) cases, respectively. The fibula was intact, repaired, and remained fractured in 9 (6.7%), 32 (23.9%), and 93 (69.4%) cases, respectively, in the infrapatellar group. There was no difference in the rate of fibular fixation between groups ($P = 0.2$). Primary angular malalignment >5° occurred in 35 patients (26.1%) with infrapatellar IMN insertion, and in five patients (3.8%) who underwent suprapatellar IMN insertion ($P < 0.0001$).

Conclusion: This is the largest patient series directly comparing the suprapatellar to infrapatellar IMN insertion technique in the treatment of distal tibia fractures. Suprapatellar IMN technique results in a significantly lower rate of malalignment compared to the infrapatellar IMN technique.

See pages 47 - 108 for financial disclosure information.

Clinical and Functional Results of 116 Patients with Knee Dislocations

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Purpose: Knee dislocations are rare injuries that may be limb-threatening and often associated with functional limitations. Treatment strategies vary among institutions, without consensus regarding timing, surgical tactic, and rehabilitation. Furthermore, high-energy and low-energy mechanisms are described that impact distinct patient populations with different risks. Our purpose is to describe the clinical results and functional outcomes of knee dislocations treated with a similar strategy and to identify risk factors for complications and poor outcomes.

Methods: 138 adult patients with knee dislocations (OTA 40A) over 14 years at one institution were reviewed; 22 had insufficient data, leaving 116: 74 (64%) male with mean age 36.9 years, mean body mass index (BMI) 30.7, and mean ISS 14.9. High-energy mechanisms occurred in 79 (68%), mostly motor vehicle (31%) and motorcycle (22%) collisions. 21 (18%) had popliteal artery injury requiring revascularization, while five others were observed. Eight patients (6.9%) had primary amputation; seven of them had vascular injuries. All others underwent initial closed reduction, and 38 patients (33%) with open injuries had urgent surgical debridement. 89% of all patients had provisional external fixation, retained for mean 6.8 weeks in 51%. Repair of medial and lateral structures and posterolateral corner occurred at mean 5.8 days (range, 0 to 26) after injury. Fixation of cruciate avulsion fractures (5 posterior cruciate ligament and 1 anterior cruciate ligament [ACL]) occurred concurrently. Due to residual instability, bicruciate reconstruction was performed in 4 patients at a mean of 29.4 weeks, while 1 other had ACL reconstruction, (4.6% with delayed cruciate reconstructions). Complications included deep vein thrombosis (DVT), pulmonary embolism, wound infection, heterotopic bone (HO), and arthrosis. Functional outcomes were measured with the Musculoskeletal Function Assessment (MFA) survey.

Results: After a mean 18 months follow-up, 63 early complications were noted in 45 patients (39%), requiring 31 (27%) to undergo 148 secondary operations, including 3 late amputations. Open knee dislocations resulted in more amputations (23% vs 1.3%, $P < 0.001$). Popliteal arterial injuries were associated with more amputations (31% vs 4.3%, $P < 0.001$), infection (39% vs 12%, $P = 0.002$), and DVT (23% vs 8.8%, $P = 0.05$). Open dislocations with arterial injuries were associated with the most complications: DVT in 77% ($P = 0.005$), infection in 54% ($P = 0.066$). Patients with wound infections were more likely to develop HO (39% vs 9.8%, $P < 0.001$) and less knee motion (98° vs 115°, $P = 0.14$). Patients with ISS ≥20 had less knee motion at six months (86° vs 122°, $P = 0.036$) and one year (91° vs 120°, $P = 0.016$). 42 patients completed MFA surveys and had a mean score of 38.9 after a minimum of 12 months.

Conclusion: Few patients (4.6%) experienced functional instability requiring late cruciate reconstruction. However, early complications occurred frequently (39%), particularly in patients with open injuries and/or arterial injury. Limitations in knee motion were associated with high ISS, infection, and HO. Mean outcome scores are poor, and data collection is ongoing, which may provide valuable information to identify modifiable risk factors. Alternative treatment strategies could be more effective in promoting recovery and function.

Superior Outcomes after Operative Fixation of Patella Fractures using a Novel Cage Plate Construct: A Prospective Cohort Study

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Purpose: Displaced patella fractures (OTA 34) traditionally have been treated with anterior tension band constructs and are associated with poor patient-reported and functional outcomes. To address these inferior outcomes, we have developed a novel fixation construct that provides multiplanar fixation through a low-profile mesh plate with minimal iatrogenic disruption to the patella vascularity. The purpose of this prospective cohort study was to determine if the new fixation construct resulted in improved outcomes compared to tension band techniques.

Methods: A prospective cohort study was performed on consecutive patients with isolated, unilateral patellar fractures. During the initial study period from 2008-2011, patients were treated with traditional tension band techniques using a combination of Kirschner wires, cannulated screws, figure-of-eight wires, cerclage wires, and/or nonabsorbable sutures. During the subsequent study period from 2012-2014, a novel cage plate construct was used that spans half of the patella circumference laterally and provides multiplanar fixation through a low profile plate (figure). Additional suture fixation of the patellar tendon to the cage plate was utilized to address inferior pole comminution. Thirty patients treated with a tension band and eleven patients treated with the novel cage plate construct were included in the study. Subjective clinical outcomes and objective functional and strength outcomes were collected at 3, 6, and 12 months postoperatively.

Results: The two cohorts had similar baseline characteristics, including average age (60.0 years and 65.5 years, respectively), gender (80% female and 82% female, respectively), body mass index (23.2. and 23.4, respectively), and medical comorbidities. Patients with the cage plate construct had clinically and statistically significant superior clinical outcome scores using the Activities of Daily Living Scale of the Knee Outcome Survey (ADLS-KOS) at both 3 months (58.7 vs 72.2, P = 0.016) and 12 months (74.9 vs 84.2, P = 0.024). Closed kinetic chain functional testing demonstrated significantly better forward lunge scores in the cage plate cohort compared to the tension band cohort at 3 and 6 months (P values <0.001-0.035). Open kinetic chain functional testing revealed significantly improved isometric, power, and endurance knee flexion in the cage plate cohort at 3, 6, and 12 months (P values 0.003-0.045). Thigh circumference difference was significantly decreased at 12 months in the cage plate cohort (1.31 cm vs 0.25 cm, P = 0.007). Anterior knee pain at final follow-up was significantly decreased in patients with the cage plate (80% vs 9%, P <0.0001).

Conclusion: Operative treatment of patella fractures using tension band constructs have resulted in impaired functional outcomes overall. In this prospective cohort study, the use of a novel fixation construct with multiplanar fixation and minimal disruption to patella vascularity has led to improved clinical and functional outcomes.

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AP (a) and lateral (b) injury knee radiographs of a patella fracture in a 50-year-old woman. 3-dimensional CT reconstructions (c) reveal an AO/OTA34-C3 patella fracture. AP (d) and lateral (d) knee radiographs 12 months postoperatively.

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Function and Knee Range of Motion Plateau 6 Months Following Tibial Plateau Fractures

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Purpose: Tibial plateau fractures are common and drastically affect patient quality of life. Adequate care and patient education are pivotal for patient recovery. The purpose of this study is to determine when function, range of knee motion (ROM), and pain levels no longer improve following tibial plateau fracture.

Methods: A consecutive series of patients who sustained a tibial plateau fracture were reviewed. Patients were evaluated postoperatively using the Short Musculoskeletal Function Assessment (SMFA), physical examination, and radiographic examination at regular intervals for a minimum of 12 months. Preoperative radiographs were reviewed, and fractures were classified based on the Schatzker classification. The cohort was divided into high- and low-energy fractures based on Schatzker classification. A Friedman test was run on each group to determine if there were differences in SMFA standardized scores, range of motion, and pain levels at 3, 6, and 12 months after surgery. Pairwise comparisons were performed with a Bonferroni correction for multiple comparisons.

Results: 84 patients with complete SMFA follow-up at 3, 6, and 12 months were identified. 78 (93%) had known ROM at all three time points. 74 (88%) had a known pain score at all three time points. Fifty patients (60%) had low-energy fractures (Schatzker 1-3). 34 patients (40%) had high-energy fractures (Schatzker 4-6). SMFA total score ($P<0.0005$) and knee ROM ($P<0.0005$) were significantly different when comparing all three time points following both low- and high-energy tibial plateau fractures. Pain level was not different at any time (High $P=0.718$, Low $P=0.760$) in either group. Post hoc analysis revealed significant differences in standardized SMFA total score, ROM, and most SMFA subscores between 3 and 6 months as well as 3 and 12 months postoperatively in both groups. There was no statistically significant difference for any of the studied metrics between 6 and 12 months in the low-energy cohort. The mobility category ($P=0.046$) and daily activities category ($P=0.033$) were the only scores to show significant differences between 6 and 12 months in the high-energy cohort.

Table 1:
Pairwise comparisons of SMFA scores between 6 and 12 months

Score	High Energy Adjusted p-value	Low Energy Adjusted p-value
Total SMFA	0.087	1.000
Function Index	0.118	1.000
Bothersome Index	0.236	1.000
Daily Activities Category	0.033*	1.000
Emotional Status Category		0.634
Mobility Category	0.046*	0.881
ROM	0.974	1.000

* Indicates significance at $p<0.05$

Conclusion: In this cohort, no significant difference in function, ROM, or pain level exists between 6 months and 12 months after treatment of low-energy tibial plateau fractures. However, there are significant differences in mobility and daily activity between 6 months and 12 months after treatment of high-energy tibial plateau fractures. Patients can be counseled that 6 months after low-energy tibial plateau fractures patients should not expect significant changes in function or ROM. However, patients with high-energy tibial plateau fractures can be counseled that they can expect continued significant changes in mobility and ability to conduct daily activities up to 12 months after surgery.

See pages 47 - 108 for financial disclosure information.

Is Early Total Care of Bicondylar Tibial Plateau Fractures Safe?

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Background/Purpose: The optimal treatment for bicondylar plateau fractures remains controversial. Contrary to popular practice, which favors staged protocols, we have used early single-stage open reduction and internal fixation (ORIF) to treat these injuries whenever possible. The purpose of this study was to determine the safety of this strategy.

Methods: We retrospectively reviewed all the patients who were treated with primary ORIF for AO/OTA type 41-C bicondylar plateau fractures in our Level I trauma institution. We selected patients for whom follow-up data were available for a minimum of 12 months. The primary outcome measurement was the reoperation rate within 12 months for repeat ORIF, irrigation-debridement (I&D) for infection or wound dehiscence, fasciotomies for compartment syndrome, treatment of malunion and nonunion, amputation, knee fusion, manipulation under anesthesia for stiffness, and hardware removal. For a subset of patients who were enrolled in a study with prospective data collection, we also evaluated functional outcome using the Short Form (SF)-36 and the Selected Functional Movement Assessment (SFMA), and analyzed the quality of fracture reduction using four radiographic criteria.

Results: 149 cases (145 patients) with AO/OTA type 41-C bicondylar plateau fractures were operated in our institution between 2005 and 2014. 80 patients were male and 65 female. The mean age of the patients was 50.8 years (range, 19-86). All but 14 fractures were closed (Gustilo I: three cases; Gustilo II: four cases; Gustilo IIIA: four cases; Gustilo IIIB: one case; Gustilo IIIC two cases). Primary ORIF was performed in 135 patients (90.6% of cases). Nine patients (6.0%) were treated with a staged protocol and five patients (3.4%) were transferred to our institution after initial treatment with an external fixator. Patients who benefited from primary ORIF were operated within 24 hours after admission in 60.0% of cases and within 48 hours in 89.7%. Eighteen patients (13.3%) who were treated with primary ORIF sustained repeat surgery within 12 months for complications. The reoperation rate was 10.4% if hardware removal was excluded. Eight patients developed a wound infection requiring I&D, 2 of them after open fractures. Three patients were reoperated for compartment syndrome requiring fasciotomies. Three patients underwent repeat surgery for nonunion and one patient for early fixation failure. Four patients were reoperated for hardware removal for pain or disturbance. No surgeries were recorded for malunion, amputation, knee fusion, or manipulation under anesthesia. Secondary outcome measurements were obtained for a subset of 39 patients who enrolled in a study with prospective data collection. For those patients, the SF-36 score changed from 56.2 for the Physical Component Summary and 51.9 for the Mental Component Summary at baseline to 52.4 and 46.0, respectively, at 12 months. In the same period, the normalized SFMA changed from 45.4 to 56.5 for Function, and 45.7 to 55.7 for Pain. In 82.1% of cases, three or four of the four radiographic criteria used to assess the quality of fracture reduction were met.

Conclusion: Provided surgery is performed without delay by experienced orthopaedic trauma surgeons, a large proportion of bicondylar tibial plateau fractures can be safely treated with primary ORIF. Early surgery does not preclude good quality of reduction, and the reoperation rate within 12 months as well as functional outcomes are comparable when confronted to published results for surgical treatments using a staged protocol.

See pages 47 - 108 for financial disclosure information.

A Novel PTH-Based Bone Graft Substitute Demonstrates Noninferiority to Autograft in a Large Phase IIb Study of Tibial Plateau Fractures

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Background/Purpose: A novel formulation containing a modified, covalently linkable parathyroid hormone (TGplPTH1-34) in fibrin with hydroxapatite/tricalcium phosphate

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.

PAPER ABSTRACTS

(HA/TCP) granules has been developed for the treatment of tibial plateau fractures (TPFs) following open reduction and internal fixation. Efficacy and safety of the product was compared to the clinical gold standard, cancellous autograft.

Methods: An open-label, controlled, randomized, dose-blinded, phase IIb study was conducted in which patients with TPFs were treated with either cancellous autograft, high concentration (1.0 mg/mL) or low concentration (0.4 mg/mL) of TGplPTH1-34 in fibrin with HA/TCP granules. The primary end point was radiological healing at 16 weeks, as measured by an independent radiology panel. Additional secondary end points included measuring radiographic healing, clinical healing, and maintenance of reduction at both earlier (6 and 12 weeks) and later (6, 12, and 24 months) time points. 183 patients were treated in the study, based on the statistical requirement of showing noninferiority to autograft with a 15% noninferiority margin.

Results: The radiographic healing rate at 16 weeks for patients with the product at the high concentration (83.6%) was demonstrated to be both statistically noninferior to that for autograft (84.5%) and superior to that for the low concentration (66.1%). In the composite end point, which combined CT and clinical outcomes, 72.1% of the patients treated with the high concentration healed compared to 63% of those treated with autograft. Maintenance of reduction was evaluated as well, with minimal loss observed (<1 mm compared to postoperative radiographs) at all time points, out to the end of the study at 24 months. Long-term follow-up demonstrated that essentially all the patients were healed in both the high-dose and autograft groups. Finally, the measured safety parameters further demonstrated that the product was well tolerated.

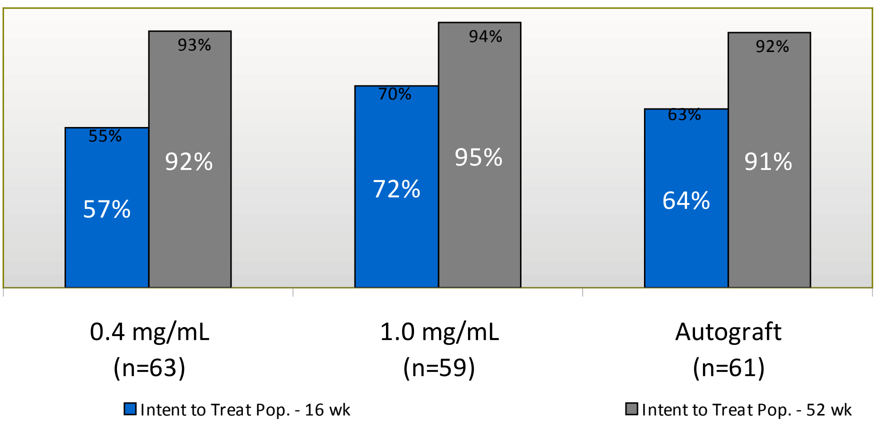

Figure: Outcomes from combined clinical and radiological healing assessment. The combined assessment for the intent to treat population at 16 wks and 52 wks is shown in the blue bars and gray bars respectively. Radiological assessment has been performed by an independent radiology panel while the clinical assessment has been performed by the investigator. At both timepoints, the healing rate following treatment with the high concentration of the PTH based product is higher than that for both patients treated with autograft as well as those treated with the lower concentration of $TGplPTH_{1-34.}$ This trend is confirmed in the per protocol analysis, which is shown in black at the top of each bar.

See pages 47 - 108 for financial disclosure information.

Conclusion: The authors have been developing a novel bone graft substitute based on the local retention of PTH in a fibrin matrix to induce bone healing. While the product has many potential applications, the initial development has been focused on the treatment of TPFs. In this study, it has been demonstrated that healing with the PTH-based product is as robust as that with autograft, throughout the entire healing process, Furthermore, at the early time points, where obtaining healing is more challenging, the product performed even better than autograft. Maintenance of reduction was measured, as this represents an important measure of the clinical outcome. Here, it was observed that the TGplPTH1-34-fibrin-granule composite provided a robust support, with no clinically relevant loss of reduction observed in the study. The combination of these data with the very clean safety profile provides a first clinical demonstration of the efficacy of the PTH-based product as a new powerful tool for fracture healing.

Functional and Clinical Outcomes of Nonoperatively Managed Tibial Plateau Fractures

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Background/Purpose: This study sought to assess and compare long-term functional and clinical outcomes in patients with tibial plateau fractures that are treated nonoperatively.

Methods: Over 8 years, 275 consecutive tibial plateau fractures were treated by two surgeons at a single institution and followed prospectively in an IRB-approved study. Overall, 28 patients (10%) were treated nonoperatively and followed for a mean 21 ± 15.5 months. All patients were treated similarly: kept non-weight-bearing for a minimum 10 weeks and prescribed a similar physiotherapy regimen. Patients were categorized into one of two cohorts based on the indication for nonoperative care: (1) minimal fracture displacement (MFD) defined as less than 2 mm of articular depression or 1 mm fracture gap or (2) surgery precluded (SP) by patient characteristics such as severe comorbidities at time of treatment or delayed presentation. Clinical follow-up included functional score, clinical examination, and radiologic evaluation. Student t tests for continuous variables and chi-square tests for categorical variables were used to assess differences between the groups. A multiple linear regression analysis of the entire cohort controlling for gender, age, smoking history, age-adjusted CCI (Charlson comorbidity index) and injury energy level was used to identify independent factors predictive of Short Musculoskeletal Function Assessment (SMFA) scores.

Results: 23 patients were available for long-term follow-up. The cohort was 48% male, 51.3 ± 15.6 years of age, and had a mean age-adjusted CCI of 0.7 ± 1.7. Overall, 57% of injuries were due to a high-velocity energy mechanism, and the fracture breakdown by Schatzker classification was as follows: 5 type I, 7 type II, 3 type III, 6 type IV, and 2 type VI. Average total SMFA at latest follow-up was 14.7 ± 18.2 points and mean VAS (visual analog scale) pain score was 2 ± 2.8. Overall, 65% (n = 15) of patients in this study attained good to excellent functional outcomes as defined by a total standard SMFA score of 15 or less. 22% (n = 5) had radiographic evidence of knee arthritis. Average knee range of motion (ROM) at latest follow-up for this cohort was 130° ± 6.5°. In the patients in whom surgery was precluded, ROM (123° ± 15.3° vs 132° ±3.8°, P = 0.03) and outcome scores (44.03 ± 19.8 vs 10.4 ± 13.6) were significantly poorer. To date, no patient had undergone total joint arthroplasty following index injury. Age was the only statistically significant predictor of total SMFA in a multiple linear regression analysis of the cohort, $F(6,16) = 5.139$, $P = 0.007$, adjusted $R2 = 0.530$.

Conclusion: A large proportion of carefully selected patients with minimally displaced tibial plateau fractures can expect good to excellent outcomes when managed nonoperatively. Patients with comorbidities precluding surgery for tibial plateau fractures at time of presentation have long-term sequelae from this injury including chronic pain and poorer functional outcomes.

See pages 47 - 108 for financial disclosure information.

Acute In Vivo Metrics of Joint Incongruity Following Articular Fracture Predict Posttraumatic Arthritis in Mice

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Purpose: Posttraumatic arthritis (PTA) occurs commonly after articular fracture. Joint degeneration may arise in part from surface incongruity after injury. Radiographic classification systems do not account for 3-dimensional (3D) geometry of the joint surface. CT-based measures of joint fracture severity have been used to predict ankle PTA development. Interestingly, the MRL/MpJ "superhealer" mouse strain is protected from PTA following articular fracture, thus providing valuable insight into the progression of PTA. Currently, the relationship between initial injury severity, articular displacement, and PTA development following articular fracture remains unknown. The objective of this study was to develop in vivo micro CT metrics of joint incongruity after articular fracture to further characterize the pathomechanism of PTA.

Methods: C57BL/6 and MRL/MpJ mice (n = 12/strain) received closed articular fractures (fx) of the tibia (Fig. 1). At 8 weeks, mice were sacrificed and assessed for arthritic changes (Mankin score). In vivo micro CT was performed pre- and post-fx, 1, 4, and 8 weeks post-fx. Displacements of the bone surface, or bone surface deviations (BSDs), were quantified for the lateral and medial tibial plateau (Fig. 1). Serum biomarkers of bone metabolism were measured pre- and post-fx to 6 weeks. BSDs were analyzed using analysis of variance and bone markers using nonparametric analyses.

Results: Temporal patterns in BSDs were significantly different between mice with larger average positive axial deviations found in C57BL/6 mice at 8 weeks post-fx (P = 0.01; Fig. 2). Mankin scores were correlated to all BSDs in both mouse strains. Acute BSDs showed the strongest correlations with PTA development. In C57BL/6 mice, axial BSDs on post-fx day 0 were highly predictive of PTA severity at 8 weeks post-fx (Fig. 3). In contrast, MRL/MpJ mice post-fx day 0 BSDs did not predict PTA development. Serum PINP (procollagen I N-terminal propeptide), a bone formation marker, in the C57BL/6 mice was significantly lower than the MRL/MpJ mice post-fx (P = 0.005), indicating a less robust acute response compared with the superhealer strain.

Conclusion: Acute displacements of the bone surface following articular fracture were predictive of arthritis development in C57BL/6 but not MRL/MpJ mice. C57BL/6 mice also showed an acute drop in serum PINP compared to MRL/MpJ mice. These findings suggest that MRL/MpJ mice undergo a unique mechanism of fracture healing following articular fracture and that joint incongruities secondary to articular fracture do not predispose MRL/MpJ mice to PTA development, whereas PTA development in C57BL/6 mice is predicted by acute bone displacements and decreased bone metabolism. In vivo CT metrics of joint incongruity provide a method for quantifying bone surface incongruities that have traditionally been difficult to measure. The translational potential of our joint incongruity metrics is high, as they could readily be applied to full-scale clinical CT scans.

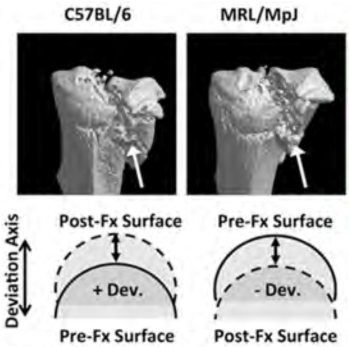

Figure 1. (Top) Micro-CT images of representative fractures. (Bottom) Metrics of joint incongruity after intra-articular fracture. Reference surface = pre-fracture; test surface = post-fracture.

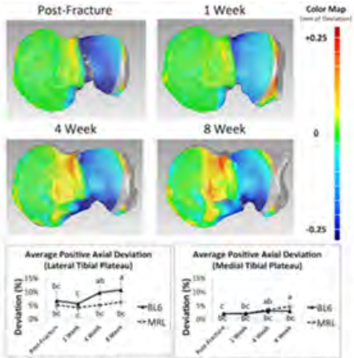

Figure 2. (Top) Representative color map of axial deviation with fracture healing. (Bottom) Significant strain-wise differences in fracture healing from post-fracture to 8 weeks.

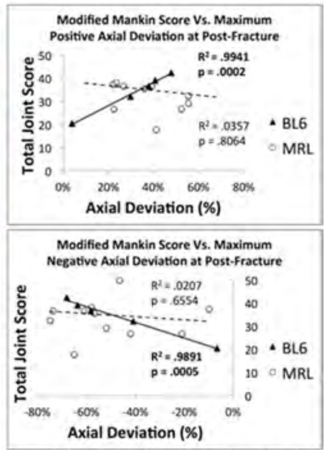

Figure 3. Correlations between total joint Mankin score for arthritis at 8 weeks post-fracture and post-fracture joint incongruity.

See pages 47 - 108 for financial disclosure information.

Decreased Bone Density in Geriatric Patients Does Not Lead to Inferior Outcomes After Open Reduction and Internal Fixation of Tibial Plateau Fractures

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Purpose: Operative fixation of periarticular fractures in elderly patients with poor bone quality can be challenging. Studies suggest that these patients may experience a higher rate of implant failure and poorer clinical outcomes when compared to younger cohorts, which has led many surgeons to pursue nonoperative management when feasible. Fractures of the proximal tibia (OTA 41.A-C), however, often present with significant articular involvement and surgical intervention is necessary to restore joint alignment and congruity. The purpose of this study was to determine if geriatric patients with decreased bone density had worse outcomes after open reduction and internal fixation (ORIF) of tibial plateau fractures when compared to younger patients with greater bone stock.

Methods: A prospective clinical registry of operatively treated tibial plateau fractures by a single surgeon was queried. Procedures were performed between 2003 and 2013 and all patients had a minimum of 1-year clinical outcomes scores including visual analog scale (VAS), Knee Outcome Survey Activities of Daily Living Scale (KOSADLS), the Lower Extremity Functional Scale (LEFS), and Short Form (SF)-36. For patients with preoperative CT scans, Hounsfield unit (HU) measurements were calculated by two reviewers on a GE Picture Archiving and Communication System (PACS) by creating three regions of interest on consecutive axial slices within the metaphyseal region of the distal femur. Values were averaged to generate a mean HU measurement, which was compared to available bone mineral densities (BMDs) for the femoral neck and lumbar spine as determined by bone densitometry (DXA). Clinical outcomes and HU measurements were analyzed between geriatric (age 65 or older) and nongeriatric cohorts.

Results: 93 patients were included for study, including 28 geriatric patients with a mean age of 73 years (range, 65-85) and 65 nongeriatric patients, mean age 48 years (range, 20-64). Cohorts were similar with regard to Schatzker classification and medical comorbidities including diabetes, hypertension, a history of smoking or alcohol abuse, and peripheral vascular disease. The nongeriatric cohort did have a significantly greater body mass index (27 vs 24, P = 0.03). HU measurements demonstrated an almost perfect intraclass correlation (ICC = 0.97), a strong correlation with lumbar BMD (r = 0.5), and a very strong correlation with femoral neck BMD (r = 0.7). HU measurements for nongeriatric patients were significantly greater than geriatric patients (136.4 vs 101.1, P <0.005), and there was no significant difference seen between the two cohorts with regard to 1-year clinical outcome scores (Table 1).

Conclusion: Although our cohort of geriatric patients demonstrated significantly decreased bone density when compared with a younger cohort, there was no significant difference observed in subjective 1-year clinical outcomes after ORIF of tibial plateau fractures. Clinicians can use this information to counsel patient with regard to expected results postoperatively. Further, presumed inferior bone quality should not deter treating surgeons from operating on elderly patients with tibial plateau fractures as they can have similar results at 1 year.

Table 1
One-year clinical outcomes comparing geriatric and nongeriatric patients treated operatively for tibial plateau fractures.

	Geriatric	Non-Geriatric	p-value
VAS	1.51	1.1	0.3851
KOS	79.9	83	0.3901
LEFS	69.7	78.21	0.0514
SF-36 PCS	45.8	48.9	0.1361
SF-36 MCS	51.2	54.8	0.0824

PCS = Physical Component Summary;
MCS = Mental Component Summary

See pages 47 - 108 for financial disclosure information.

Plateau Indicators for Intervention after Operative Treatment (PIVOT) Score Identifies Patients at Risk of Poor Functional Outcome After Tibial Plateau Fracture

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Purpose: The ability to predict postoperative outcomes following the surgical management of tibial plateau injuries would help identify patients at risk of diminished functional outcomes for whom aggressive interventions may provide benefit. This study seeks to develop a simple score that can accurately predict functional outcomes for patients following operative management of tibial plateau fractures.

Methods: 228 operative tibial plateau fractures treated at a single institution were prospectively followed and included in this study. Demographics, injury classification, radiographic measurements, and Short Musculoskeletal Function Assessment (SMFA) scores were collected at routine intervals. Since total SMFA scores were found to plateau 6 months postoperatively in our cohort, this time point was chosen as the predictive target. The diminished outcome cohort (DOC) was defined as any patient with a functional SMFA subdomain greater than 10 points above the mean. Logistic regression was used to build a predictive formula for cohort membership (PIVOT Score) (Figure 1). No outliers were removed. Odds ratios (ORs) were calculated and are reported as 95% confidence intervals. An area under the receiver operator characteristic curve (AUROC) value was calculated to define the overall predictive capacity.

Results: At the 6-month postoperative time point, significant predictors of poor outcome were male gender (OR = 0.09-0.75; P = 0.013), Caucasian race (OR = 0.03-0.36; P = 0.0004), smoking history (OR = 1.81-28.33; P = 0.005), age (OR = 1.02-1.11; P = 0.003), and fracture pattern involving the tibial spine (OR = 1.97-16.48; P = 0.001). The final formula (Figure 1), created through logistic regression, was found to be a significant predictor of poor outcome (Nagelkerke R Square = 0.45; Hosmer and Lemeshow = 0.39, AUROC = 0.86). After assigning every patient a PIVOT Score, we identified 2 cutoff values that divided the cohort into 3 groups. Below 25% (low risk), 7% of patients had a diminished outcome. Between 25% and 50% (intermediate risk), 46% of patients had a diminished outcome. Above 50% (high-risk), 72% of patients had a diminished outcome.

Conclusion: The PIVOT Score is a significant predictor of 6-month diminished functional outcome. Patients scoring >25% are considered either intermediate or high risk for a diminished functional outcome. Early interventions aimed at improving functional outcomes can be targeted to these patients.

Figure 1:Tibial Plateau Diminished Outcome Score
*Probability of Diminished Outcome = 1 / (1 + exp(-(-3.38-1.38*MALE 2.27*WHITE+1.97*SMOKER+0.06*AGE +1.74*TIBIALSPINE)))*
Male (dichotomous variable; 1- yes, 0 - no); White (dichotomous variable; 1- yes, 0 - no); Smoker (dichotomous variable; 1- yes, 0 - no); Age (continuous variable); Tibial Spine Involvement (dichotomous variable; 1- yes, 0 - no)

Objective Metric of Energy Absorbed in Tibial Plateau Fractures Corresponds Well to Clinician Assessment of Fracture Severity

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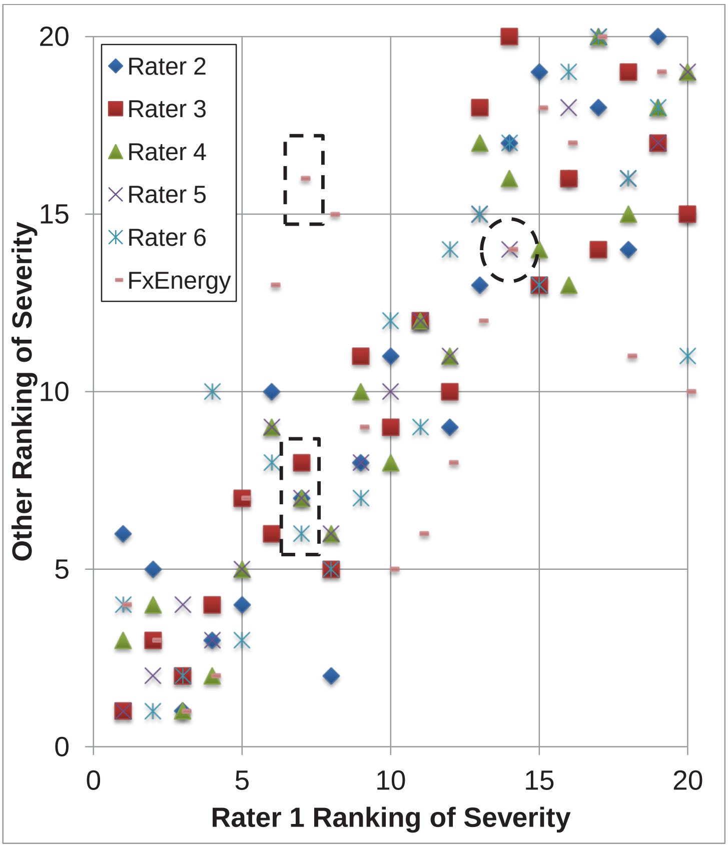
Background/Purpose: Outcomes of intra-articular fractures are influenced both by acute mechanical damage and by residual chronic changes in joint loading. The extent of damage sustained in the acute setting reflects the energy absorbed in creation of the fracture; therefore, fracture energy can be expected to substantially influence clinical outcomes. Previous investigations have demonstrated that objective CT-based quantification of fracture energy in pilon fractures correlates with surgeon assessment of injury severity and 2-year radiographic outcomes. It is not clear whether these findings can be extrapolated to other articular fracture types. In this work, we explored whether this technique of fracture energy measurement could be used to stratify the severity of tibial plateau fractures. Specifically, we hypothesized that a CT-based measure of fracture energy would correspond to subjective surgeon assessment of fracture severity. We tested the hypothesis by comparing surgeon rank ordering of fracture severity for a series of tibial plateau fractures with CT-based measurements of fracture energy.

Methods: Twenty fractures were selected from a series of 50 tibial plateau fractures to span a full spectrum of severity. Fracture classification ranged from OTA 41-B1 to 41-C3. Six fellowship-trained orthopaedic trauma surgeons independently rank-ordered the fractures in order of severity using AP and lateral knee radiographs. The only instructions given to the raters were to rank the cases in order of least to most severely injured. Subjectively, they used the number and size of fragments, the amount and direction of displacement, percentage of articular surface involved, and whatever other features they felt were important based on their clinical experience. CT-based image analysis techniques were used to quantify the fracture energy. The software identifies all fracture fragments on CT imaging and calculates the amount of bone surface area liberated by the fracture. The previously validated algorithm incorporates fracture liberated surface area and bone density to provide the fracture energy measurement. The agreement between fracture severity assessments made by the surgeons and the ranking by fracture energy measurement was tested by computing their concordance. A pair of cases' injury severity rankings was deemed concordant if the case with the higher ranking of injury severity for one rater also had the higher ranking for a second rater. Simply put, the rate of concordance is the number of concordant pairs divided by the total number of possible pairings.

Results: Concordance between the six orthopaedic surgeons ranged from 82% to 93%. Concordance between surgeon severity ranking and fracture energy ranged from 73% to 78% (Fig. 1).

See pages 47 - 108 for financial disclosure information.

Figure 1: Representative rank-ordering of fracture severity by six orthopaedic trauma surgeons and by fracture energy. The y-axis represents severity ranking as assigned by raters 2-6 and according to the calculated fracture energy. The x-axis represents the rank ordering of rater 1. As an example, there was high agreement between rater 1 and raters 2 – 6 at rater-1 injury number 7, but this fracture's rank according to fracture energy calculation was much higher (black dashed boxes). At rater-1 injury number 14, the rank according to fracture energy was the same as the rank assigned by raters 1 and 5 (dashed circle).



Conclusion: There is a high level of agreement between surgeon assessment of tibial plateau fracture severity and CT-based measurement of fracture energy. In addition, agreement among six surgeons with extensive clinical experience judging injury severity was excellent. Taken together, these results confirm that a CT-based method of calculating fracture energy accurately portrays fracture severity as judged clinically for tibial plateau fractures and provides an objective way to quantify injury severity. In addition, it is likely this tool will be clinically useful as there was excellent surgeon agreement on fracture severity. Further research is ongoing to characterize the relationship between fracture energy and clinical outcomes. Funding: Research reported in this abstract was supported by the National Institute of Arthritis and Musculoskeletal and Skin Diseases of the National Institutes of Health under award number R21AR061808. The research was also aided by a grant from the Foundation for Orthopaedic Trauma.

The Effect of Soft Tissue Injuries on Clinical Outcomes Following Tibial Plateau Fracture Fixation

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Purpose: Tibial plateau fractures (OTA 41A-C) have a high incidence of soft-tissue injuries with rates of meniscal and ligament tears ranging from 47% to 99%. Previous studies have focused on injury patterns that are associated with these soft-tissue injuries. However, the clinical significance and the indications for surgical treatment of meniscal and ligament tears in the setting of tibial plateau fractures have not been established. The purpose of this study was to determine if soft-tissue injuries and subsequent secondary surgeries altered clinical outcomes following fixation of tibial plateau fractures.

Methods: A prospective database of operatively treated tibial plateau fractures by a single surgeon from 2004-2012 was used to identify patients. Inclusion criteria consisted of patients with injury radiographs, preoperative knee MRI, and a minimum of 12 months of clinical outcomes. MRI analysis was performed prior to operative fixation by a fellowship-trained musculoskeletal radiologist to detect tears in the medial and lateral menisci and complete ruptures of the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL). Standard anterolateral and/or posteromedial approaches were used for fracture fixation as indicated by fracture pattern. Lateral meniscal tears were routinely repaired following lateral submeniscal arthrotomy, whereas other soft-tissue injuries were not addressed acutely. Clinical outcomes included the Knee Outcome Survey Activities of Daily Living Scale (KOSADLS), the Lower Extremity Functional Scale (LEFS), the Short Form (SF)-36, and knee range of motion (ROM) at the most recent postoperative visit. Subsequent secondary soft-tissue surgeries and arthroplasties were also recorded at final follow-up.

Results: 82 patients were included in the study. Average patient age was 54 years (range, 13-87), and 51% were male. 55 fractures (67%) were classified as Schatzker I or II, and the remaining 27 (33%) were classified as Schatzker IV, V, or VI. Postoperative clinical outcome scores were obtained at a mean of 31 months (range, 12-111). Using MRI to diagnose soft-tissue injuries, 49 patients (60%) had a lateral meniscal tear and 32 patients (39%) had a medial meniscal tear. MCL ruptures were seen in 23 patients (28%), LCL ruptures in 9 patients (11%), ACL ruptures in 8 patients (10%), and PCL ruptures in 2 patients (2%). 33 patients (40%) were diagnosed with injuries to multiple structures. Only four patients (5%) had a secondary soft-tissue surgery and one patient (1%) underwent total knee arthroplasty at final follow-up. Patient-reported outcomes (KOSADLS, LEFS, SF-36) and ROM assessments were not significantly different in patients with and without medial meniscal tears, in patients with and without lateral meniscal tears, and in patients with and without MCL ruptures. Patients with LCL, ACL, and PCL ruptures were too few for meaningful analyses.

See pages 47 - 108 for financial disclosure information.

Conclusion: While injuries to menisci and ligaments are common in patients with tibial plateau fractures, the clinical significance and treatment algorithms for these injuries have not been defined. In this cohort of patients with operative tibial plateau fractures, we confirmed a high frequency of soft-tissue injuries using MRI. With a minimum of 12 months of follow-up in these cohorts, meniscal and MCL injuries did not significantly affect clinical outcomes. Only five patients (6%) underwent a secondary soft-tissue surgery (4) or arthroplasty (1) at midterm follow-up. Given the small number of patients with other ligament injuries in this cohort, subsequent studies in larger cohorts will be important to pursue these results.

Operative Versus Conservative Management of Displaced Tibial Shaft Fractures in Adolescents

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Purpose: Despite the commonplace nature of displaced tibial shaft fractures in adolescents, there is wide variability in management strategies. The purpose of this study was to assess treatment outcomes and determine predictors of failure in patients treated for displaced tibial shaft fractures.

Methods: We retrospectively reviewed all patients aged 12-18 years who presented to one of two Level I trauma centers with a displaced tibial shaft fracture that required reduction. Exclusion criteria included open fractures and lack of follow-up to either radiographic union or to 6 months from the index procedure. Fractures were treated based on surgeon preference with one of two approaches: (1) closed reduction and casting (CRC) under conscious sedation or general anesthesia, or (2) immediate operative fixation with a rigid intramedullary nail or flexible nails. Radiographic healing was defined as bridging of 3 of 4 cortices on radiographs and adequacy of final fracture alignment was defined as less than 5° of angular deformity and less than 1.0 cm of shortening. Outcomes were analyzed both on intent-to-treat principles and by definitive treatment method.

Results: 74 patients were included, of which 17 were initially managed with operative fixation and 57 with CRC. While all fractures in both cohorts achieved bony healing, 23 of the 57 patients who underwent initial CRC failed closed treatment and ultimately required operative intervention (40.3%). Multivariate analysis of patient and fracture characteristics revealed initial fracture displacement of >20% of the tibial width (odds ratio [OR] = 7.8, P <0.05) and the presence of a fibula fracture (OR = 5.06, P = 0.05) as independent predictors of closed treatment failure. Patients managed operatively had longer hospital stays (5.4 vs 1.9 days, P <0.001), fewer clinic visits (4.8 vs 5.9, P <0.01), a higher incidence of anterior knee pain at healing (20% vs 0%, P <0.01) and trended towards better final alignment (92.5% adequate vs 72.4%, P = 0.10). There were no differences between cohorts with respect to time to radiographic healing, final range of motion, and return to activity.

Conclusion: Treatment outcomes between initial operative fixation and attempted closed reduction of displaced tibia fractures in adolescents are similar, but treatment failure is higher in CRC. Predictors of CRC failure include initial fracture displacement >20% and presence of a fibula fracture. Patients must be counseled about the high failure rates with CRC and the need for active follow-up during treatment, whereas those undergoing surgical management should understand the risk of anterior knee pain and prolonged hospitalization.

See pages 47 - 108 for financial disclosure information.

PAPER ABSTRACTS

Fracture Classification Predicts Functional Outcomes in Supracondylar Humerus Fractures: A Prospective Study

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Purpose: This study was conducted to prospectively evaluate the relationship between fracture classification and functional outcome in children with supracondylar humerus fractures (SCHFX) using validated outcome measures.

Methods: An IRB-approved prospective enrollment of consecutive patients with operative SCHFX was performed over a 3-year period. Fracture pattern and Gartland classification were recorded by the treating surgeon at the time of surgery. Functional outcome was assessed at final follow-up using the Pediatric Outcomes Data Collection Instrument (PODCI) and the QuickDASH Outcome Measure, an abbreviated version of the Disabilities of the Arm, Shoulder and Hand questionnaire. Multiple regression analysis was used to determine the relationship between fracture classification/pattern and functional outcome while controlling for other injury parameters including patient age, neurologic deficit, vascular abnormality, and presence of an open fracture.

Results: 752 patients were enrolled during the study period of whom 199 (average age 6.7 years) completed functional outcome measures at final follow-up. Of these, 10 patients (5%) sustained flexion injures and 189 (95%) sustained extension injuries of which 62 (33%) were Type II fractures and 127 (67%) were Type III fractures. 65 (34%) of the extension injuries were posteromedially displaced, 58 (31%) were posterolaterally displaced, 54 (29%) were posteriorly displaced without coronal plane deformity, and 12 (6%) were multidirectionally unstable. The average PODCI global functioning scale score and QuickDASH scores for the entire cohort were 93.5 and 10.5 respectively indicating excellent function. No differences in outcome scores were noted between patients with Type II fractures, Type III fractures, and those with multidirectional instability. For extension injuries, no difference in outcome was identified based upon fracture pattern. Flexion injuries demonstrated significantly lower PODCI transfer and basic mobility (93.9 vs 98.7, $P < 0.001$) and PODCI pain and comfort scores (77.8 vs 94.8, $P < 0.3$) than Type III extension injuries. As a whole, extension injuries demonstrated significantly higher PODCI pain and comfort scores (94.8 vs 77.8, $P < 0.02$) than flexion injuries.

Conclusion: This is the first study to prospectively determine an association between fracture classification and functional outcome using validated outcome measures following the operative treatment of children with SCHFX. While children generally have excellent functional outcomes following the operative treatment of SCHFX, flexion injuries may be predictive of poorer outcomes with regards to pain and mobility when compared to extension injuries at final follow-up.

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.

Factors that Predict Instability in Pediatric Diaphyseal Both Bone Forearm Fractures

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Background/Purpose: Diaphyseal forearm fractures are among the most common fractures in children. Significantly displaced or angulated fractures are treated with initial closed reduction and immobilization, with follow-up to determine if displacement occurs. The purpose of this study was to determine what factors upon initial presentation would predict failure of initial closed reduction and casting.

Methods: Radiographic and hospital records of skeletally immature patients who underwent closed reduction and casting of diaphyseal forearm fractures in the emergency department were evaluated. Demographic, time course, and radiographic data were evaluated at presentation and at varying time intervals until union was achieved. Univariate logistic regression analysis of these factors was performed to identify predictors of failure of initial closed reduction and immobilization as defined as requiring a repeat procedure.

Results: 188 patients meeting the inclusion criteria were identified and analyzed. 174 patients had adequate follow-up to union. The average patient age was 7.7 years old and 68% of patients were male. A total of 19 patients underwent a repeat procedure. Patients who underwent a repeat procedure had an average initial reduction time of 36.9 ± 22.2 minutes, whereas those patients who did not require additional procedures had an initial reduction time of 23.4 ± 11.8 minutes (P <0.0103). Odds of requiring repeat reduction were the greatest in those patients who presented with fractures translated greater than or equal to 50% in any plane (odds ratio [OR] = 10.1; 95% confidence interval [CI] 3.1-33.1), age greater than 9 years (OR = 4.1; 95% CI 1.5-11.3), complete fracture of the radius (OR = 9.1; 95% CI 2.0-40.5), follow-up angulation of the radius >15° on lateral radiographs (OR = 5.0; 95% CI 1.3-18.6), follow-up angulation of the ulna >10° on AP radiographs (OR = 8.7; 95% CI 2.7-28.4), and follow-up translation of either bone >50% (OR = 13.5; 95% CI 4.5-40.2). There was no significant correlation with respect to initial angulation parameters and cast index.

Conclusion: Patients requiring lengthy initial reductions are at an increased risk of having a repeat procedure than those with short initial reduction times. Age, initial translation, complete fractures of the radius, and residual translation on follow-up are highly predictive of patients having repeat procedures. These patients require carefully monitored follow-up and families should be counseled appropriately as to their risk of repeat intervention.

See pages 47 - 108 for financial disclosure information.

Best Trauma Paper of the 2015 POSNA Annual Meeting
Implementation of a Standardized Clinical Assessment and Management Plan (SCAMP) for Pediatric Distal Radius Fractures: Effect on Quality and Care

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Background/Purpose: Standardized Clinical Assessment and Management Plans (SCAMPS) have been proposed as a means of improving quality, safety, and cost-effective care. The purpose of this investigation was to evaluate the effect of a distal radius fracture (DRF) SCAMP on clinical care and resource utilization.

Methods: 199 patients treated from October 2010 to March 2012 prior to the initiation of the DRF SCAMP (pre-SCAMP) were compared to 384 patients treated from August 2012 to April 2013 after DRF SCAMP implementation (post-SCAMP). All patients were 4 to 18 years of age with acute DRFs. Exclusion criteria included open fractures, pathologic fractures, refractures, and vascular insufficiency. Mean patient age was 10.5 years. Approximately 45% of patients sustained torus fractures, 40% bicortical metaphyseal fractures, and 15% physeal fractures. There were no significant differences between the pre- and post-SCAMP cohorts with respect to age, gender, or fracture type. Radiographic alignment was assessed at each encounter. Acceptable radiographic alignment was deemed <10° angulation and 50% translation or <20° angulation and 50% to 100% translation for older and young patients, respectively. Remanipulation, surgical intervention, and complications were recorded.

Results: Torus fractures: All patients with torus fractures achieved satisfactory clinical healing with nonoperative care. However, following SCAMP implementation, there was significant improvements in avoidance of casting (99% pre-SCAMP vs 28% post-SCAMP), appropriate use of splinting (1% pre- to 72% post-SCAMP), and avoidance of unneeded follow-up clinical visits after 3 weeks of immobilization. Bicortical metaphyseal and physeal fractures: While there were no significant changes in remanipulation or surgery rates, there were significant decreases in rate of initial fracture reduction after SCAMP implementation (68% pre- vs 53% post-SCAMP). There were also increased rates of acceptable alignment after the first encounter (86% pre- vs 99% post-SCAMP) and at the 6-week post-injury mark (83% pre- vs 98% post-SCAMP). Overall: Throughout the post-SCAMP period, there was a trend for decreased number clinical visits and radiographs for all patients. Over time, adherence to the SCAMP approached 82% to 100%. No cases of compartment syndrome, malunion, or postsurgical infection were recorded.

Conclusion: Implementation of a DRF SCAMP resulted in equivalent clinical outcomes, improved adherence to best practice guidelines, decreased number of clinical visits and radiographs (and thus cost of care), and high provider acceptance. SCAMPs are an effective tool to improve clinical care and resource utilization. Further investigation is underway to characterize accompanying reductions in cost in the DRF model.

PAPER ABSTRACTS

Factors Associated with Development of Nonunion or Delayed Healing Following Open Fracture: A Prospective Cohort Study of 736 Subjects

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Purpose: We sought to evaluate the factors associated with nonunion following open long bone fractures (humerus, radius/ulna, femur, tibia/fibula) including the relationship between time to initial surgical management. Secondarily, we examined factors associated with development of delayed healing.

Methods: Between 2001 and 2009, 736 subjects with 791 open fractures were enrolled in a prospective cohort study undertaken at 3 Level Itrauma centers and followed for 1 year. Demographics and injury information (Gustilo grade, fracture site, injury mechanism, timing of antibiotic administration, and initial surgery) were recorded. Subjects were evaluated postoperatively using standardized data forms until the fracture healed. Phone interviews were undertaken at 1 year. Nonunion was defined as unplanned surgical intervention after definitive wound closure or incomplete radiographic healing at 1 year post fracture. Delayed union was defined as lack of progression of radiographic healing at 2 consecutive postoperative visits or incomplete radiographic healing and ongoing clinical symptoms between 6 months and 1 year post fracture. Univariate logistic regression was undertaken for age, gender, time from injury to surgery, and antibiotic administration calculated in hours, Gustilo grade and fracture location (upper extremity, femur, tibia/fibula), presence of deep infection, smoking status, comorbid conditions, having associated injuries, multiple fractures, and receiving a transfusion. Two multivariate logistic regression models using nonunion and delayed union (yes/no) as dependent variables were developed.

Results: The mean age was 41.5 ± 17.1 years and 530 (72%) were male. Fractures occurred in motor vehicle accidents (n = 359 [49%]), falls (n = 230 [31%]), crush injuries (n =131 [18%]) and assaults (n = 16 [2%]). Tibia/fibula fractures were most common (n = 413 [52%]), followed by upper extremity (n = 285 [36%]) and femur (n = 93 [12%]) fractures. Follow-up (1 year interviews and/or clinical follow-up of >90 days) was completed by 695 (94%) subjects (746 fractures). Overall, 124 (17%) subjects had nonunions while 63 (10%) subjects experienced delayed healing. The median time to initial surgery was 9.0 hours(h) (interquartile range [IQR] 6.8, 12.0) for healed fractures and 8.3 h (IQR 6.3, 11.3) for nonunions (P = 0.36). The median time to surgery was 9.0 h (IQR 7.0, 12.5) for fractures without healing problems, and 8.0 h (IQR 5.5, 12.3) for those with delayed healing, respectively (P = 0.34). Multivariate logistic regression also showed no significant association between time to initial operative management and developing nonunion (odds ratio [OR] 0.97; 95% confidence interval [95% CI] 0.92, 1.01) or experiencing delayed healing (OR 0.96; 95%CI 0.90, 1.02). Deep infection (OR 12.75; 95% CI 6.1, 26.8), Gustilo grade 3A relative to grade 1 fractures (OR 2.5; 95% CI 1.3, 4.8) and smoking (OR 1.7; 95% CI 1.1, 2.8) retained a significant association with developing a non-union in the multivariate model. Deep infection (OR 4.3; 95% CI 1.2, 15.5) and Gustilo Grade 3B/C relative to grade 1 (OR 3.7; 95% CI 1.4, 9.4) fractures were significantly associated with delayed healing.

Conclusion: Development of nonunions or delayed healing is strongly associated with the presence of a deep infection and higher Gustilo grade fractures.

See pages 47 - 108 for financial disclosure information.

PAPER ABSTRACTS

A Predictive Model of Tibial Shaft Fracture Nonunion at the Time of Definitive Fixation

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Background/Purpose: A clinical tool that would allow surgeons to predict the likelihood of nonunion at the time of intramedullary nail (IMN) fixation of tibial shaft fractures could change the management of those at high risk of nonunion. Previous authors have explored possible factors influencing reoperation in tibial shaft fractures; however, no authors have developed a tibial shaft nonunion prediction model for the time of initial fixation for fractures treated with reamed IMNs (time zero). We posited that commonly collected data on patients, evaluation of the fracture and soft-tissue injury and postoperative films at the time of definitive IMN fixation, would allow us to extract statistically significant variables predictive of nonunion. Employing these variables we aimed to create a nonunion prediction model that would enable surgeons to predict nonunions in tibial shaft fractures at the time of IMN fixation.

Methods: Our final study group consisted of 382 adult patients treated with IMN for tibial shaft fractures (n = 56 progressed to nonunion, n = 326 healed without further intervention). All patients were followed to fracture healing or surgical intervention for nonunion and we excluded patients with adequate follow-up but indeterminate healing status. Importantly, no patients were included who had planned nonunion surgery, typically based on large fracture gap. We reviewed perioperative and follow-up radiographs, charts, and laboratory data. We defined nonunions as fractures expected to heal without further intervention that eventually, in the surgeon's judgment, required an additional operative intervention to ensure union. We collected patient data on 35 factors thought to contribute to delayed bone healing. Bivariate and multivariate regression techniques, as well as stepwise modeling approaches, were used to examine the relationship between variables available during the index hospitalization and subsequent nonunion. Over 26 variables were examined in the analysis but found to be insignificant. Nine factors were found to be significant.

Results: A multiple variable logistic regression model was developed that included 7 significant factors ($P < 0.05$ and odds ratio >2.0 in bivariate or multiple variable models): use of flap, open fractures, compartment syndrome, male gender, American Soceity of Anesthesiologists (ASA) classification, percent cortical contact, and chronic disease status (HIV/HepC/diabetes). Additionally, we found spiral fractures and low-energy mechanism predictive of union. Based on these factors we developed a model titled the Nonunion Risk Determination (NURD) score. The NURD score assigns 1 point per level for ASA and % cortical contact, 1 point for male gender, 2 points for open fracture, 3 points for chronic conditions, 4 points for compartment syndrome, and 5 points for requiring a flap. One point each was subtracted from the score for spiral fractures or low-energy injury. Patients with a NURD score of 0 to 5 had a 1.72% chance of nonunion (4/232). Patients with a NURD score of 6 to 8 had a 22% chance of nonunion (22/101), Patients with a NURD score of 9 to 11 had a 42% chance of nonunion (13/31), and patients with a NURD score >12 had a 61% chance of nonunion (11/18).

Conclusion: We determined that a number of factors predict nonunions and can reliably be formed into a union prediction model to allow clinicians to determine very early in the treatment course which patients have a higher risk of nonunion. The ability to predict nonunion early in the patient's course may help guide patients and clinicians as to when patience (as union is likely) is the best approach and when interventions aimed at enhancing healing of the fracture through earlier surgical interventions may be reasonable options.

See pages 47 - 108 for financial disclosure information.

Prospective Prediction of Tibial and Femoral Shaft Fracture Nonunion at 4 Months

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Purpose: A retrospective single-center study recently determined that the presence or absence of bridging callus at 4 months postoperatively accurately discriminated between tibial shaft fractures bound for union and nonunion. However, there remains no consensus regarding early prognostication of long bone nonunion. The purpose of this study was to prospectively assess the accuracy and reliability of the previously described assessment of any bridging callus at 4 months in a prospective cohort expanded to include both tibial and femoral shaft fractures.

Methods: A prospective prognostic study is being performed at a Level I trauma center. To date we have identified 78 consecutive tibial (OTA 42-A,B,C) and femoral (OTA 32-A,B,C) shaft fractures treated with intramedullary nailing. Ten patients had yet to achieve a final healing outcome, while others were excluded due to death before final outcome (2), early planned bone grafting for critical bone loss (1), and failure to return to clinic (5). Thus, the final analytic cohort included 60 fractures (26 tibias and 34 femurs). Postoperative digital radiographs were obtained between 3 and 4 months postoperatively and assessed independently by three orthopaedic traumatologists for the presence of bridging callus. The patients were followed to radiographic and clinical union. The accuracy of varying callus criteria (any bridging, bicortical bridging, and tricortical bridging) was assessed with the chi-square test for ability to predict union and nonunion. Interobserver reliability (kappa statistic) was calculated for each criterion.

Results: The nonunion rate was 6.7% (4 of 60). The presence of any bridging callus by 4 months postoperatively accurately predicted union when present and nonunion when absent (56/56 and 4/4 respectively, $P < 0.001$). This included the prediction of nonunion in both the tibia (3/26) and femur (1/34) without error. Bicortical bridging was accurate for 59 of 60 (98.3%), predicting union when present and nonunion when absent (55/55 and 4/5, respectively, $P < 0.001$), incorrectly predicting one healing fracture as a nonunion. Tricortical bridging was accurate for 50 of 60 fractures (83.1%), predicting union when present and nonunion when absent (46/50 and 4/14, $P = 0.01$), incorrectly predicting ten healing fractures as nonunions. Interobserver reliability was calculated for any bridging callus (kappa = 0.96), at least bicortical bridging (kappa = 0.89), at least tricortical bridging (kappa = 0.58), and the exact number of cortices bridged (kappa = 0.51).

Conclusion: Prospective assessment for any bridging callus by 4 months postoperatively predicted union and nonunion with high accuracy and reliability. This clinical criterion is simple, reliable, and requires only standard radiographic views. 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 risks overestimation of the nonunion rate and is associated with relatively poor reliability.

Ketorolac Administered in the Recovery Room for Acute Pain Management Does Not Affect Healing Rates of Femoral and Tibial Fractures

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PAPER ABSTRACTS

Background/Purpose: Ketorolac is a nonsteroidal anti-inflammatory drug that is used effectively as a postoperative analgesic. Orthopaedic surgeons have been reluctant to use this medication in the setting of fracture repair because its mechanism of action disrupts the first phase of bone healing, and therefore may increase the risk of nonunion. The purpose of this study is to compare the healing rates of acute femoral and tibial shaft fractures in patients who were administered ketorolac in the postanesthesia care unit (PACU) to the healing rates in patients who did not receive ketorolac.

Methods: This was a retrospective review of skeletally mature patients who underwent intramedullary rodding of a femoral shaft (OTA 32) or a tibial shaft (OTA 42) fracture at a single institution from 2003 to 2013. Patients were divided into two groups: those who received ketorolac in the PACU or on the floor within the first 24 hours after the surgical procedure (Group 1), and those who did not (Group 2). Minimum 1-year clinical and radiographic follow-up was required. The primary end points were reoperation for repair of a nonunion and time to union. Data collection included age, gender, extent of soft-tissue injury, diabetes, smoking status, and dosage of ketorolac. Statistical analysis utilized Fisher's exact test for categorical variables and Mann-Whitney U test for continuous variables with significance set at P value less than or equal to 0.05.

Results: Group 1 consisted of 80 patients (52 tibia, 33 femur) and Group 2 consisted of 233 patients (139 tibia, 94 femur). Patient demographics were similar between the two groups. Average time to union of the femur was 147 days for group 1 and 159 days for group 2 (P = 0.57). Average time to union of the tibia was 175 days for Group 1 and 175 days for Group 2 (P = 0.57). There were three femoral nonunions (9%) in Group 1 and eleven femoral nonunions (11.7%) in Group 2 (P = 1.00). There were three tibial nonunions (5.8%) in Group 1 and seventeen tibial nonunions (12.2%) in Group 2 (P = 0.29). All patients with a nonunion in the study group were current smokers. The average dose of ketorolac given to the patients who developed a nonunion and those who went on to heal was 47 mg and 98 mg, respectively.

Conclusion: Ketorolac administered in the first 24 hours after acute fracture repair for acute pain management does not appear to have a negative impact on time to healing or incidence of nonunion for femoral or tibial shaft fractures.

See pages 47 - 108 for financial disclosure information.

Posttraumatic Tibial Defects Treated by the Ilizarov Method: Comparison of Classic Versus Integrated Technique

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Background/Purpose: Limb salvage in the presence of posttraumatic tibial bone loss can be accomplished using the Ilizarov method. Internal fixation at the beginning of the consolidation phase stabilizes the regenerate and allows for early removal of the external fixator. We compared patients with posttraumatic tibial bone loss treated with either a circular external fixator exclusively, termed the "classic technique" (Fig. 1) or a combination of a circular external fixator and plating or insertion of an intramedullary nail during the consolidation phase, termed "integrated technique" (Fig. 2). We asked: (1) Does integrated fixation decrease the time in the external fixator? (2) Is there a difference in the rate of complications between the two groups? and (3) Are the results obtained at final follow-up comparable?

Methods: 58 consecutive patients (58 tibiae) with posttraumatic tibial bone loss were retrospectively identified. Patients were divided into two groups, "classic technique" (30 patients) and "integrated technique" (28 patients). The mean follow-up was 33 months (range, 6-90). IRB approval was obtained prior to initiation of the study. Baseline demographics, surgical variables, and outcomes were compared. Adverse events were reported as problems, obstacles, or complications as described by Paley. Functional and radiographic outcomes were reported using the Association for the Study and Application of Methods of Ilizarov (ASAMI) scoring system.

Results: Baseline demographics were similar in both groups. Mean tibial bone loss was 5.3 cm (range, 1.6-13) and 50% of patients were actively infected. Patients treated with integrated fixation had significantly less time ($P < 0.001$) in the external fixator, 7 months (range, 1.3-15) compared with 11 months (range, 4.5-15). There were 49 adverse events in 31 patients (17 problems, 31 obstacles, 1 minor complication). There was no difference in the severity ($P = 0.8703$) or number ($P = 0.359$) of complications between both groups. Overall, patients required a mean of 4.05 surgical procedures (range, 2-5) for limb salvage. There was no difference ($P = 0.2194$) in the incidence of unplanned surgical procedures (obstacles) between groups. All patients had no recurrence of infection and all had bony union at final follow-up. Good-to-excellent ASAMI function, and bone scores were obtained in 100%, and 98% of patients, respectively.

Conclusion: Limb salvage with distraction osteogenesis in the presence of posttraumatic tibial bone loss is a challenging surgical entity. The integrated fixation method allows for earlier removal of the external fixator while the frequency of adverse events and ability to restore limb lengths are similar in both groups. A mean of 4.05 surgical procedures were required for tibial reconstruction. Adverse events did occur in 53% of patients; however, good/excellent results can be expected in all patients with proper management.

Figure 1. A, Antero-posterior, and **B**, lateral x-rays of a 34 year-old male with a 6 cm distal tibial metaphyseal defect. The patient was treated with the "classic method" of distraction osteogenesis, **C**,**D**. Final result, **E**, **F**, with restoration of limb-lengths and normal coronal and sagittal alignment. Time in frame: 302 days.

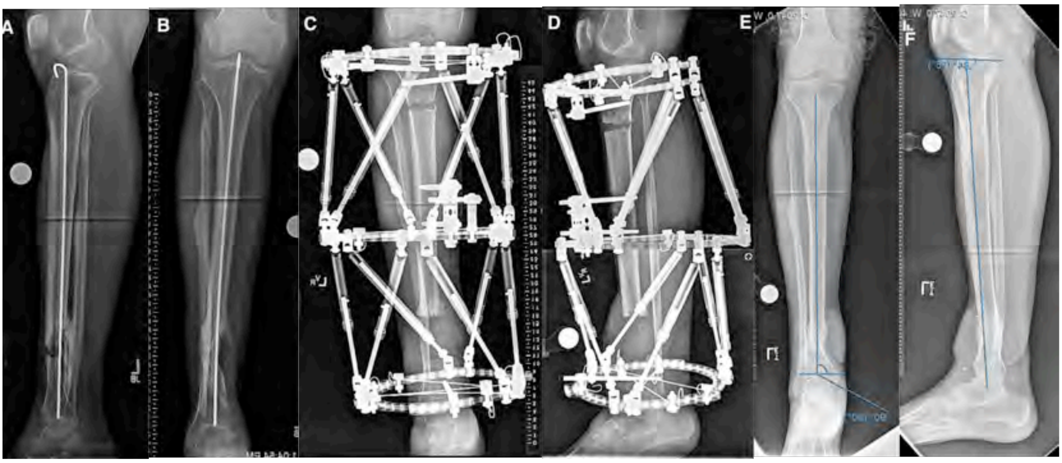
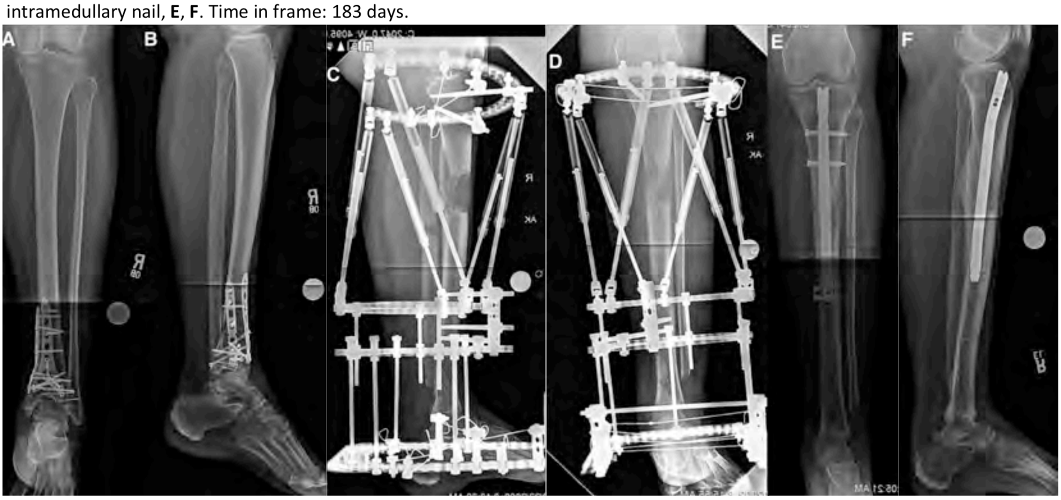


Figure 2. A, Antero-posterior, and **B**, lateral x-rays of a 50 year-old female with an infected Pilon fracture and 4 cm of nonviable bone at the ankle joint. Patient was treated with "integrated fixation", lengthening, **C**, **D**, and then insertion of an intramedullary nail, **E**, **F**. Time in frame: 183 days.



See pages 47 - 108 for financial disclosure information.

Is This Autograft Worth It? The Blood Loss and Transfusion Rates Associated with RIA Bone Graft Harvest

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Purpose/Background: The previous decade has witnessed the emergence of the reamer-irrigator-aspirator (RIA) as a widely used method of bone graft harvest. The literature is sparse regarding complications associated with RIA. One small series focused on donor-site morbidity compared to conventional methods such as anterior or posterior iliac crest. To date no papers have examined the rate of blood loss or transfusion in a group larger than eight patients. We hypothesized that the hematocrit drop and transfusion rates after RIA harvest would be much greater than historical controls for iliac crest bone graft harvest since the RIA technique attaches suction directly to the intramedullary canal.

Methods: We conducted a retrospective chart review of all patients who underwent RIA bone graft harvest from January 2008 to December 2014. A search of our electronic record system yielded 65 patients who underwent RIA autograft harvest. Demographic information, date of surgery, indication for surgery, type of surgery, preoperative hematocrit (HCT), postoperative HCT, transfusion rate, reported intraoperative blood loss, reported volume of graft harvested, and other major complications were recorded.

Results: A total of 61 (94%) patients were included in the study as there were insufficient preoperative data to include 4 patients. Mean patient age was 51 years (range, 18-80), with 32 males and 29 females. The most common indications for an RIA was tibial nonunion (51%) followed by femoral nonunion (39%), ankle fusion (8%), and bilateral calcaneal nonunions (2%, one case). The femur was used for graft harvesting in 49 cases with the tibia being used in the remaining 12 cases. The amount of harvested bone graft was reported in 40 cases and averaged 53 mL (rang,e 30-100 mL). The mean HCT drop postoperatively was found to be 13.7 (range, 4.1-27.4) with operative reports documenting a mean estimated blood loss (EBL) of 674 mL (range, 100-2000). EBL was noted to be much higher than historical data that suggest EBL with Iliac crest bone grafting ranges from 336 mL to 371 mL. A total of 27 patients (44%) required a blood transfusion for a mean postoperative HCT of 22.0. The majority of those transfused received two units of packed red blood cells (range 1-4 units). There were no documented cases of iatrogenic fracture or fat emboli syndrome.

Conclusion: This series demonstrated that 44% of patients undergoing RIA bone graft harvest required transfusion, with a mean hematocrit drop of 13.7 across all subjects. This is certainly significantly higher than the risk of transfusion associated with iliac crest harvest. The EBL intraoperatively, which is widely acknowledged as a very unreliable estimate, was also greater than double that of historical controls for iliac crest. Given the likelihood of blood transfusion, risks associated with this must be factored into the decision to utilize RIA for the harvest of autogenous bone graft.

PAPER ABSTRACTS

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.

Treatment of Hypovitaminosis D in an Orthopaedic Trauma Population

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Purpose: The purposes of this study were to (1) determine the incidence of hypovitaminosis D in an urban trauma population and (2) evaluate a vitamin D supplementation intervention strategy. We hypothesized that if given a free sample, patients would exhibit high adherence and their vitamin D levels would become sufficient.

Methods: 62 consecutive skeletally mature patients were treated surgically over 4 months for acute fractures of the pelvis or extremities by one traumatologist. Baseline calcium and vitamin D intake was recorded, and vitamin D levels were measured, serving as our initial study group to determine the prevalence of hypovitaminosis D. Subsequently, 144 patients were treated by the same surgeon for acute fractures, serving as the intervention group. All patients were prescribed 600 mg calcium and 800 U vitamin D3 capsules to take twice daily. For those patients discharged to home, they were provided with a free bottle (6-month supply) of calcium/D supplement with instructions. Vitamin D levels were obtained at time of injury and after approximately 6 to 8 weeks of supplementation. Patients were surveyed in the outpatient clinic to determine adherence to the supplement, dietary intake of vitamin D, and exposure to the sun.

Results: 62 consecutive patients, including 34 men and 26 women, with mean age 55 years (range, 19-95) were all deficient for vitamin D, except two (3.2%) who were taking supplements prior to injury. Mean baseline level was 17.4 ng/mL (sufficient is >30ng/mL). The intervention group (n = 144) consisted of 91 men and 53 women, with mean age 45 years (range, 14-98), and mean body mass index 28.1 (range, 16.1-47.4). Ethnicity was 69% Caucasian, 26% African American, and 2.1% Hispanic. Most common mechanisms of injury were motor vehicle collision 47%, low-energy fall 25%, and fall from height 15%. Mean baseline vitamin D level in the intervention group was 19.9 ± 11.4 ng/mL. Ten (6.9%) were taking vitamin D prior to injury, and 80% of them had a sufficient level. All others (mean baseline level 16.9 ± 6.9 ng/mL) were prescribed calcium and vitamin D and were offered free supplements when discharged to home. 77 patients completed surveys, and mean vitamin D level (n = 74) was 36.3 ng/mL after a mean of 10.4 weeks of supplementation (P <0.0001). 79% reported adherence or partial adherence to supplement recommendations. All adherent patients had achieved normal vitamin D levels at follow-up. 16 patients were nonadherent, with 10 who forgot to take the supplement, and 6 choosing not to take the supplement.

Conclusion: Hypovitaminosis D was present in 100% of our orthopaedic trauma patients who were not already taking vitamin D supplements. The intervention was effective in decreasing the prevalence of hypovitaminosis D within several weeks, with all supplemented patients achieving normal levels. 79% of patients adhered to recommendations. Further study to determine the long term cost-effectiveness of this strategy appears warranted.

See pages 47 - 108 for financial disclosure information.

Incidence of Complications After Therapeutic Anticoagulation in the Postoperative Spine Trauma Patient

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Background: There have been numerous studies on prophylactic anticoagulation after spinal surgery but none have investigated the risks of therapeutic doses of anticoagulation indicated for the treatment of a thromboembolic event such as PE (pulmonary embolism), DVT (deep venous thrombosis), or MI (myocardial infarction). The incidence of complications secondary to initiation of therapeutic anticoagulation, including spinal epidural hematoma, has yet to be established.

Methods: A retrospective cohort study was conducted using prospectively collected data at a Level I trauma center. Patient selection criteria included those who: (1) underwent spinal surgery and (2) sustained a symptomatic PE, DVT, or MI thus requiring the initiation of therapeutic anticoagulation. Patients were excluded if: (1) the thromboembolic event was sustained before spinal surgery or (2) anticoagulation was subtherapeutic. Of 1712 patients who underwent spine surgery at our institution from 2001 to 2014, 63 patients met these criteria. A control group of 63 operative spine trauma patients who did not undergo therapeutic anticoagulation were obtained and compared. Logistic regression models were used to evaluate the association between covariates of interest and odds of reoperation.

Results: Initial anticoagulation was obtained by heparin infusion, LMWH (low molecular weight heparin), and warfarin in 32 (50.7%), 29 (46.0%), and 2 (3.2%) patients, respectively. After postoperative initiation of therapeutic anticoagulation, 11 (17.5%) patients sustained complications requiring unplanned reoperation with 10 of 11 patients returning within the first 26 days compared with 4 (6.3%) patients in the control. Two (3%) patients underwent re-exploration due to the development of epidural hematomas after therapeutic anticoagulation compared to 0 patients in the control group. Patients required reoperation for indications including wound infection, hemorrhage, and pseudarthrosis. In addition, the initial use of a heparin infusion compared to LMWH demonstrated a 13.3-times higher odds for reoperation due to a spinal surgery complication and a 17.9-times higher odds for reoperation for any reason in our multivariate model.

Conclusion: This represents the first attempt to quantify complications secondary to therapeutic doses of anticoagulation after spine surgery. We found a nearly three times higher rate of complications requiring reoperation in the therapeutic anticoagulation group compared to the control group (17.5% vs 6.3%). Surgical decompression for epidural hematoma was required in 3% of anticoagulated patients versus 0% in our control group. Furthermore, our data suggest that initial anticoagulation using a heparin infusion compared to LMWH may increase the rate of reoperation.

PAPER ABSTRACTS

Can Thrombelastography Predict Venous Thromboembolic Events in Patients with Spine Trauma?

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Purpose: Despite increased bleeding risk during the acute trauma resuscitation, trauma-induced coagulopathy is associated with greater likelihood of hypercoagulability, and eventual venous thromboembolic events (VTEs). Rapid thrombelastography (r-TEG) is a whole blood assay that identifies both hypo- and hypercoagulable states. It has been shown that an elevated maximal amplitude (mA) value on admission can identify general trauma patients with increased risk of VTE. We hypothesized that (1) the risk of VTE is higher in patients with spine trauma than those without and (2) an elevated admission mA value could be used to identify patients with spine fractures at risk for VTE during initial hospital admission.

Methods: This is a retrospective review of a prospectively collected database of 9090 trauma patients admitted to an urban Level I trauma center between September 2009 and February 2011. We then evaluated only those patients who met highest-level trauma activation criteria, were 18 to 85 years of age, and were direct scene transports. Patients with burn wounds greater than 20% total body surface area or who died within 30 minutes of arrival were excluded. Two groups were created, one presented with a spine fracture (SPINE) and those without a spine fracture (non-SPINE). VTEs were defined as those pulmonary emboli (PEs) confirmed by CT angiography and those symptomatic deep vein thromboses (DVTs) confirmed by venous duplex. Univariate analyses were conducted followed by purposeful regression analysis.

Results: 3005 patients met the inclusion criteria (722 SPINE, 2233 non-SPINE). SPINE patients were older (36 vs 33 years), were more likely to be white (61% vs 52%), and blunt trauma (93% vs 74%); all P <0.05. SPINE patients were more badly injured according to individual systems AIS (Abbreviated Injury Scale) scores, all P <0.001. They also had lower systolic blood pressure (117 vs 130), higher pulse (100 vs 95), and lower Glasgow Coma Scale (GCS) (9 vs 13) on arrival; all P <0.05. Despite more hypocoagulable r-TEG values on arrival (alpha angle 72 vs 73 and mA 63 vs 64, both P <0.05), SPINE patients had higher rates of VTE (8.5% vs 3.4%, P <0.001) and PE (5.2% vs 2.4%, P <0.001). Stepwise regression generated three values to predict development of VTE (SPINE, ISS, and mA >65). After controlling for gender effect, admission mA = 72 (odds ratio 4.81) was an independent predictor of VTEs during hospitalization.

Conclusion: Admission r-TEG mA values can identify patients with spinal injuries who present with an increased risk of in-hospital DVT and PE. Patients presenting with admission r-TEG mA value of 72 are at a 4.81-fold increased risk for in-hospital VTE. Admission r-TEG values can help to identify patients at greatest risk for VTE and best target those who might benefit from an early, aggressive prophylaxis strategy.

See pages 47 - 108 for financial disclosure information.

Narcotic Requirement Is Not Predictive of Adult Traumatic Compartment Syndrome

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Background/Purpose: The diagnosis of compartment syndrome is often difficult to make, especially in the nonverbal or obtunded patient. In the pediatric trauma population, increased narcotic requirement has been thought to be a predictor of compartment syndrome. However, the presence of these signs and symptoms may be unreliable. The purpose of this study was to assess the presence of classic physical examination findings, pain medication requirements prior to fasciotomy, and changes in vital signs to identify predictors of compartment syndrome. We sought to asses if narcotic requirement is a predictor of adult compartment syndrome in the trauma patient and hypothesized that it is not.

Methods: A case-control study of patients, admitted to a Level I trauma center between 2007 and 2012, who were diagnosed with compartment syndrome and underwent fasciotomies (n = 47) compared to a randomly selected control group of trauma patients (n = 47) matched for age, extremity, and mechanism of injury, was conducted. Objective data including heart rate, systolic blood pressure (SBP), pain score (based on visual analog scale), narcotic requirement prior to surgery, and time from injury to fasciotomy (cases) or open reduction and internal fixation (controls) were obtained from the medical record. In addition, the of presence of the "6 Ps" (pain, paresthesia, pallor, paralysis, pulselessness, and poikilothermia) was recorded. Differences in these parameters were compared between cases and control patients.

Results: 17.4% of cases had 2 of the "6 Ps" compared with 2.1% of control patients ($P < 0.05$). Patients with compartment syndrome presented with pain on passive stretch in 43% of cases compared to none of the controls ($P < 0.05$) as well as significantly more frequent decrease in sensation and "firm/tight" compartments. There was a significant difference in the mean heart rate in the last 4 hours and mean heart during the interval period between the cases versus controls by approximately 10 beats per minute (99.95 vs 87.9, 98.6 vs 89.4, respectively; $P < 0.05$). The mean SBP in the last 4 hours prior to surgery was also different in cases versus controls by approximately 10 mm Hg (142 vs 130, $P < 0.05$). The mean narcotic requirement in the cases versus controls in the last 4 hours prior to surgery was not significantly different. We also did not find an increased rate of narcotic administration in the cases or controls.

Conclusion: In our patient population, a score of at least 2 out of the "6 Ps" was predictive of compartment syndrome compared to a score of less than 2. Heart rate, SBP in last 4 hours, presence of "tight compartments," and decreased sensation were also significantly associated with fasciotomy. Narcotic requirements and patient reported pain scores were not significant predictors of compartment syndrome. In an adult trauma population the classic "6 Ps" in addition to pulse rate and SBP may be more useful indicators of developing compartment syndrome and should be closely monitored in the at-risk patient.

Microdialysis Detects Ischemic Change Early in the Evolution of Acute Compartment Syndrome

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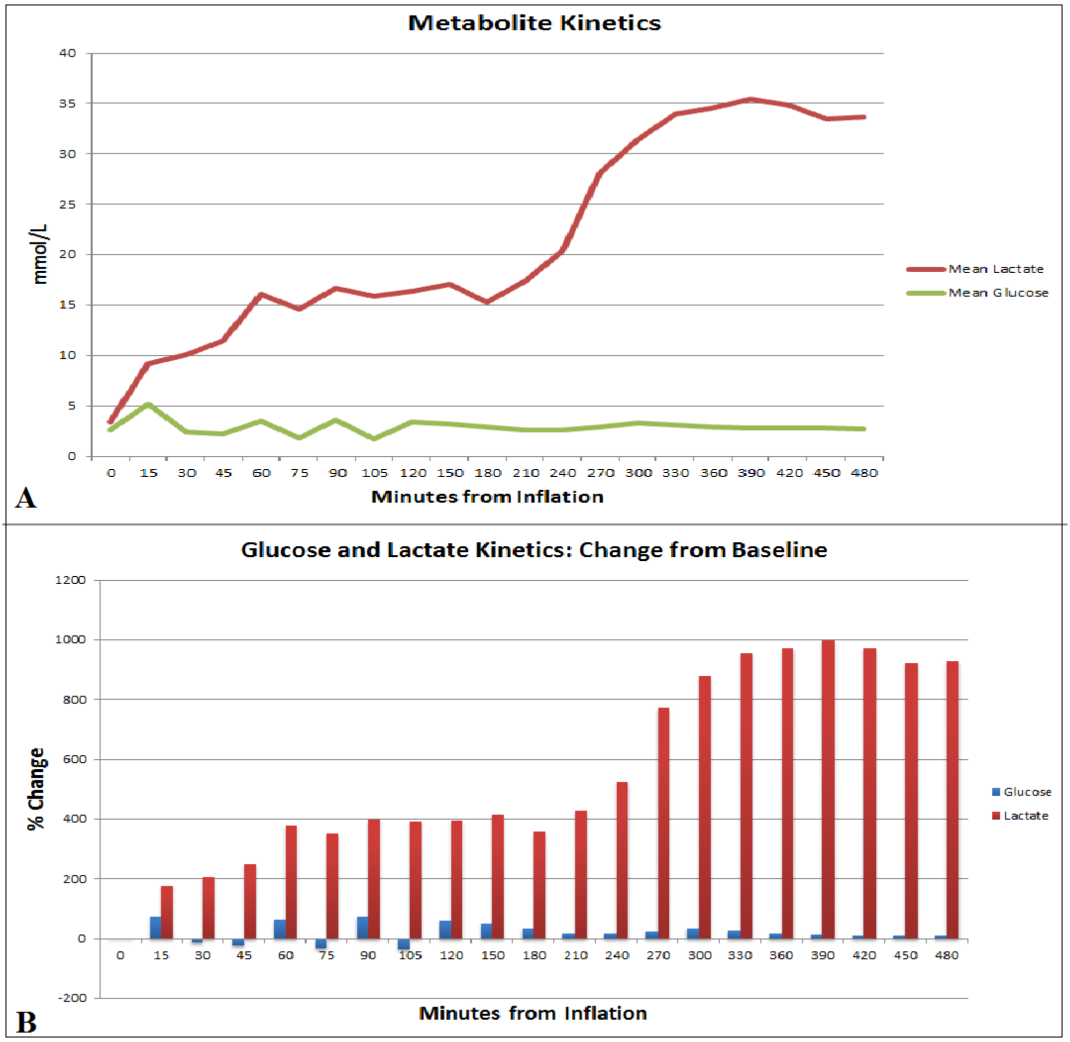
Purpose: Acute compartment syndrome (ACS) develops when intracompartmental pressure (ICP) elevates to a level impairing local muscle perfusion. In the setting of ischemia and hypoxia, myocytes transition from aerobic to anaerobic cellular respiration. Currently, microdialysis technology is used in the neurosurgical setting to detect evidence of brain hypoxia. The purpose of this study is to determine whether microdialysis is capable of detecting local extracellular metabolic changes in skeletal muscle indicative of ischemia secondary to ACS.

Methods: Following International Animal Care and Use Committee (IACUC) approval, an ACS was created in the anterior compartment of New Zealand White rabbits' legs using a previously validated balloon inflation model. After submuscular placement of the balloon, an intramuscular microdialysis (mDialysis) catheter was placed. The balloon was inflated and compartment pressures were measured using an Intra-Compartmental Pressure Monitor (Stryker). Dialysate was collected at 30-minute intervals over an 8-hour period. Glucose and lactate levels were recorded at each point and a lactate-glucose ratio was determined. Pearson's correlation coefficient (r) was used to determine correlation between glucose and lactate levels.

Results: An average ICP of 52 mm Hg was maintained via balloon inflation (mean delta P = 8 mm Hg). Mean intracompartmental glucose levels increased from 2.6 mmol/L at baseline to 5.2 mmol/L at 15 minutes. After this initial surge, glucose levels remained fairly constant over the remaining time (Figure 1A). Lactate underwent steady increase, indicating progressive ischemia. At 60 minutes, lactate levels had increased 377% from baseline and this was maintained through 180 minutes. Between 210 and 330 minutes, there was another marked increase in lactate (427% to 955%). Lactate remained markedly elevated (>900% from baseline) through the remainder of the trial (Figure 1B). The lactate-glucose ratio steadily increased from 1.4 at baseline to 10.1 at 75 minutes. This ratio peaked and remained elevated over the subsequent 7 hours and 15 minutes. There was a high correlation ($r = 0.91$) between percent change in glucose and lactate levels (from immediately previous values) in the first 60 minutes and this correlation gradually diminished by 2 hours ($r = 0.65$) and remained steady over the remainder of the trial ($r = 0.65$ at 8 hours).

Conclusion: Myocytes undergo predictable transition to anaerobic metabolism in the setting of ACS-induced ischemia, resulting in the steady production of lactic acid. This study is the first to demonstrate that microdialysis is capable of detecting local ischemia in acute compartment syndrome. In addition, microdialysis was able to elucidate local extracellular glucose and lactate kinetics that have been previously unreported in the setting of ACS. We believe this technology may provide a more sensitive and specific method of diagnosing ACS, can be used easily in the clinical setting, and may yield information leading to novel therapeutic strategies for prolonging muscle viability in the setting of ACS.

See pages 47 - 108 for financial disclosure information.



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.

Anatomic Reduction of Acetabular Fracture: When Is the Best Time to Operate?

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Purpose: Quality of reduction following surgical intervention for displaced acetabular fractures directly correlates with functional outcomes. Matta reported an increased rate of anatomic acetabular reduction when surgical fixation was performed within 2 weeks from injury ($P = 0.06$). The purpose of this study was to further stratify the timing of surgical intervention as it relates to the quality of reduction for acetabular fractures. We hypothesize that earlier intervention improves the probability of achieving an anatomic reduction.

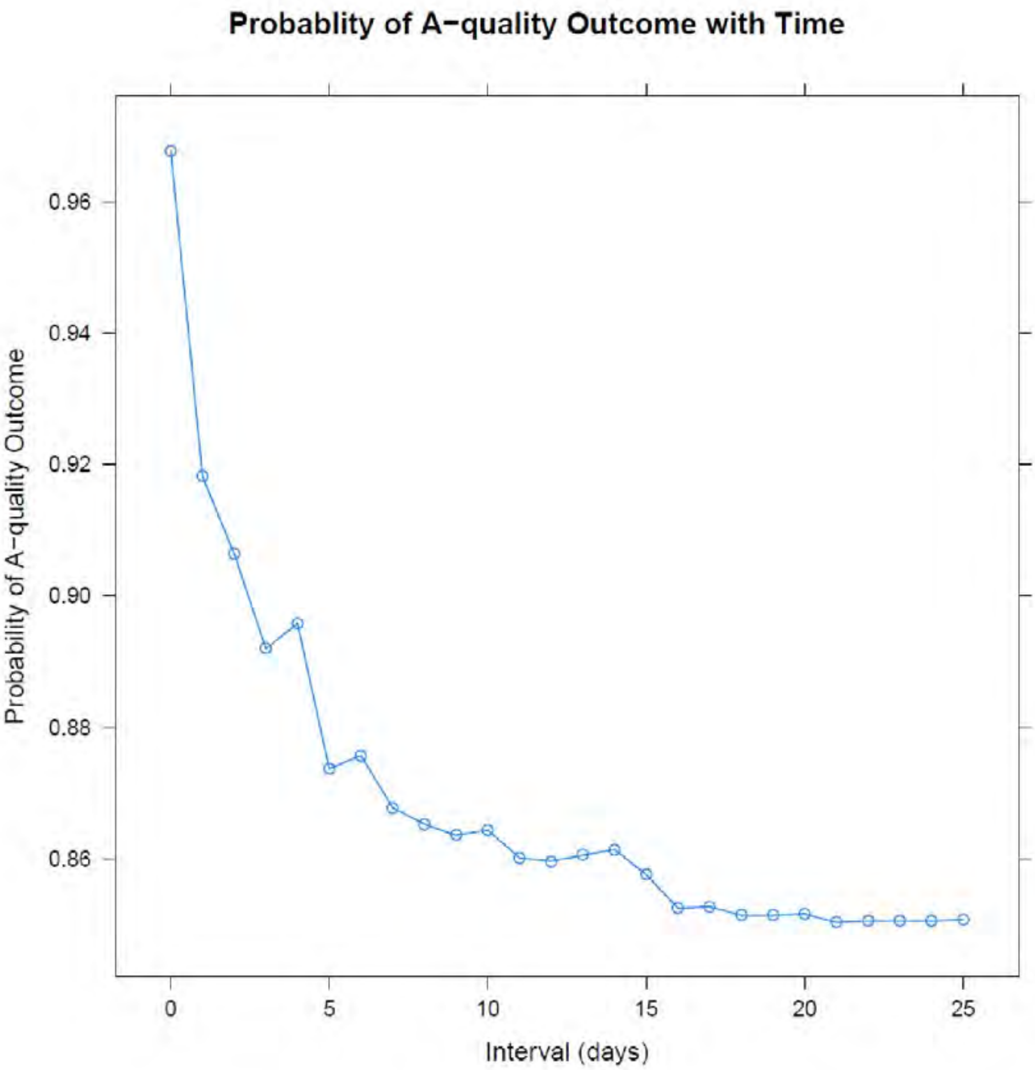
Methods: This is an IRB-approved evaluation of a prospectively collected acetabular fracture database from a single surgeon at a Level I trauma center. Reduction quality of all acetabular fractures treated via open reduction and internal fixation (ORIF) between September 2001 and February 2014 was assessed using three standard postoperative radiographs (AP and two 45° oblique Judets) as well as intraoperative fluoroscopy. Displacement of >1 mm was considered an anatomic reduction (A), 2-3 mm imperfect (I), and >3 mm poor (P). A total of 729 fractures were available for analysis. 79 of these fractures underwent percutaneous fixation in situ and were excluded, leaving a cohort of 650 fractures. The primary outcome measurement was quality of reduction as it relates to the interval from injury to ORIF (OR interval). Secondary outcome measurements included demographic and injury characteristics. The correlation between OR interval and quality of reduction was evaluated using a pairwise Wilcoxon rank-sum test and logistic regression analysis.

Results: There were no statistically significant differences between anatomic reductions (A) and nonanatomic reductions (I, P) in regards to gender, body mass index, mechanism of injury, use of skeletal traction, marginal impaction, wall comminution, or femoral head injury ($P > 0.05$). Nonanatomic reduction was related to increased age, increased ISS, fracture pattern, surgical approach, the absence of a hip dislocation, and increased OR interval ($P < 0.05$). A reductions were observed in 85% (n = 553) of cases, I reductions in 11% (n = 74) of cases, and P reductions in 4% (n = 23) of cases. Patients with A reductions had significantly shorter OR intervals (median, 3 days) when compared to either I (median, 4.5 days; $P = 0.02$) or P reductions (median, 7 days; $P < 0.001$) reductions. The OR interval of I reductions was also significantly shorter than that of P reductions ($P = 0.02$). Logistic regression analysis demonstrated that OR interval had an effect of -0.12, meaning that the log odds of anatomic reduction decreases by 0.12 with each day from injury to ORIF.

Conclusion: The interval from injury to operative fixation of acetabular fractures affects quality of reduction. Earlier intervention improves the probability of achieving an anatomic reduction. Acetabular fixation should be performed within 5 days of injury when possible.

PAPER ABSTRACTS

See pages 47 - 108 for financial disclosure information.



PAPER ABSTRACTS

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.

The Effect of 3-Dimension Printing Modeling for Treating Complex Acetabular Fractures: A Randomized Prospective Study

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Background/Purpose: Treating complex acetabular fractures presents a risk of malreduction due to difficulty in conceptualizing the fracture orientation and recreating the normal anatomy. There is also a risk of inadvertent penetration of the joint by the screws used during instrumentation. Inadequate preoperative planning can increase the times and blood loss during the operation. Fracture modeling using 3-dimension printing can precisely replicate the 3-dimensional osseous structures. This is not only helpful in understanding the fracture configuration, but also preoperative templating and contouring of the plates and planning various screw trajectories. Using the 3-dimension printing modeling for preoperative planning and surgery simulation, our goal was to evaluate the effect of 3-dimension printing modeling for treating complex acetabular fractures through a randomized prospective study, especially focus on operating time, blood loos, reduction, and position of internal fixator.

Methods: This study tests the hypothesis that use of 3-dimension printing can significantly improve technical ability on complex acetabular fractures. Fifty cases with complex acetabular fractures were randomly and equal divided into two groups, with group 1 using conventional radiographs and 3-dimensional CT for preoperative planning, and group 2 using conventional radiographs, 3-dimensional CT, and 3-dimension printing modeling for preoperative planning and simulation surgery by the surgeon and the first assistant--recording operative time, blood loss, reduction, internal fixation position,and satisfaction of the surgeon by an investigator who did not attend the process from preoperative planning to the end of operating. The accuracy of reduction was evaluated with postoperative CT scans.

Results: All operations were completed by the same senior surgeon and assistant. Time of operation: Statistically significant difference was determined between group 1 and group 2, respectively: 202 ± 50 minutes, 179 ± 62 minutes. Blood loss: Statistically significant difference was determined between group 1 and group 2, respectively: 600 ± 200 mL, 450 ± 150 mL. According to the Matta classification radiographic grades were excellent in 12, good in 8, poor in 5 in group 1 and excellent in 16, good in 6, poor in 3 in group 2; in group 1 there was one case with screw into joint and two cases with one screw out of bone, five cases with screw that was short. In group 2, two cases with screw short. Satisfaction of the surgeon: Statistically significant difference was determined between group 1 and group 2, respectively:19 (76%) cases, 23 (92%) cases.

Conclusion: 3-dimension printing technology promises to be extremely versatile and can be used in preoperative planning and surgery simulation. It is beneficial for reducing operating time and blood loss, and also helps to reduce the fracture and insert the screws as the surgeon desired.

See pages 47 - 108 for financial disclosure information.

Does Injury Mechanism Influence Eventual Conversion to THA After Acetabular Fractures in Geriatric Patients?

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Background/Purpose: Geriatric acetabular fractures are increasing in prevalence in the US. Controversy exists regarding the optimal treatment of these injuries. Although open reduction and internal fixation (ORIF) is the preferred treatment for young patients, some advocate treatment with total hip arthroplasty (THA). Many surgeons believe that acetabular fractures sustained through a low-energy mechanism are more likely to fail after ORIF. Our hypothesis was that geriatric acetabular fractures sustained after low-energy falls are more likely to progress to THA than those sustained after high-energy mechanisms.

Methods: Between 2000 and 2008 all records from a single trauma center were reviewed for patients who were greater than 60 years old and who underwent operative treatment for acetabular fractures. During this time period all fractures were treated with ORIF and no patients received acute arthroplasty. There were 115 fractures in 115 patients. 64 patients sustained their injury from a high-energy mechanism, and 51 patients had low-energy mechanisms. High-energy mechanisms were defined as motor vehicle collisions, falls from height (greater than three steps), and bicycle or motorcycle accidents. All patients had a minimum of 2 years follow-up. Mean follow-up was 61 months (range, 24-97 months). Our primary outcome measure was aseptic failure, defined as conversion to THA after initial ORIF. Mean age at time of injury was 70 years (range, 60-91) in the high-energy cohort, and 69 years (range, 60-94) in the low-energy cohort. Fisher exact test was used for the analysis.

Results: There was a statistically significant increased rate of conversion to THA in the high-energy cohort (20%, 16/51) versus the low-energy cohort (5%, 3/51, P = 0.03). The mean time to THA was 32 months (range, 5-67 months). There was one surgical site infection in the high-energy cohort, and no infections in the low-energy cohort (1.6% vs 0.0%, P = 1.0).

Conclusion: In contrast to our hypothesis, we found that geriatric patients who sustain acetabular fractures from high-energy mechanisms may be more likely to fail after ORIF and require THA than those who sustained injury from low-energy falls. This contradicts the existing dogma that patients who sustain acetabular fracture from low-energy mechanisms, and presumably are therefore more debilitated and perhaps have worse quality bone than those who sustain hig- energy injuries, will have an unacceptable failure rate with attempts at ORIF. Clinicians should be aware that low-energy mechanism alone does not appear to be an obvious contraindication to ORIF of geriatric acetabular fracture.

Long-Term Hip Joint Survival and Clinical Results in Conservatively Treated Acetabular Fractures

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Background/Purpose: Nonoperative treatment of acetabular fractures is indicated in patients with no or minor fracture displacement. There are few studies describing the long-term results for patients treated conservatively according to modern principles. The purpose of the present work was to investigate the long-term survival of the native hip joint and the clinical results following a conservatively treated acetabular fracture.

Methods: Since 1994 all acetabular fractures treated at our department have been prospectively registered. In this study we included all patients treated nonoperatively from 1994 to June 2004; 236 patients were identified. For the survival analysis, all patients who were not diseased or expatriated within the first year after injury were included. 186 patients with 187 fractures were available for analysis. The average follow-up was 9 years (range, 1-20). The average patient age was 49 years (range, 12-92), and men constituted 78% of the study population. Data were analyzed for survival of the native acetabulum with Kaplan-Meier and log-rank test to identify differences in survivorship between groups. 104 patients with surviving hip joints had an average clinical follow-up of 12 years (range, 9-20), with Harris hip score (HHS) and Merle D'Aubigné score.

Results: Twelve patients received a total hip arthroplasty during the follow-up period, on average 6.9 years (range, 1.4-15.9) after injury. Thus, the average 10-year hip joint survival was 94% (95% confidence interval [CI] 89%-97%) and 20-year survival was 85% (95% CI 66%-94%).The surviving hip joints had an average HHS of 93 (range, 28-100) and Merle D'Aubigné score of 16.6 (range, 8-18). The most significant negative predictor for survival and clinical outcome was an intra-articular step >2 mm, as measured in the obturator oblique radiographic projection. The presence or absence of fracture lines in the upper 10 mm of the weight-bearing dome on CT scans did not predict differences in survival or clinical scores. When the data was stratified in roof arc more or less than 45°, there was a significant decrease in survival for the posterior roof arc (P = 0.05) as measured on the obturator oblique radiographs. The Letournel fracture classification did not predict hip joint survival or clinical outcome. There was no difference in survival, HHS, or Merle D'Aubigné score between genders or in age over or under 60 years.

Conclusion: For acetabular fractures with minimal dislocation the long-term survival and clinical outcome is excellent. Intra-articular step and roof arc <45° as measured on plain radiographs and in the obturator oblique projection in particular is the most significant predictor of survival. Conventional radiographs with oblique projections (Judet views) are a valuable tool when deciding treatment strategy for acetabular fractures, especially when nonoperative treatment is considered.

See pages 47 - 108 for financial disclosure information.

∆ Surgery for Unilateral Sacral Fractures: Are the Indications Clear?

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Background/Purpose: Sacral fractures comprise approximately 75% of pelvic fractures. The most common type is a unilateral sacral injury with anterior impaction of the sacrum. Some prospective data have identified that these injuries do not displace over time and can be managed nonoperatively. Other surgeons believe that displacement may occur without stabilization, and are more aggressive in their approach. Additionally, sacral fractures may be complete and present with displacement. We designed a multicenter prospective trial to evaluate unilateral sacral fractures that is funded by the OTA. The purpose of this report is to compare the demographic, fracture, and displacement characteristics of the first 250 patients in this trial to determine what differences exist between the groups treated operatively versus nonoperatively.

Methods: Over a 7-year period we offered enrollment to all patients with unilateral sacral fractures in 16 centers. Exclusion criteria were: APC (anterior-posterior compression) injuries as demonstrated by symphyseal dislocation, pregnant patients or prisoners, and those who would not be able to follow up. All fractures were evaluated for location by zone and displacement (in mm) on the standard three views of the pelvis and CT scan. Displacement was measured at the level of the sacrum on all radiographs and CT. Vertical displacement was measured on the AP radiograph and "posterior" displacement on the inlet view. Additionally, the status of the anterior and posterior cortices of the sacrum were graded as impacted/nondisplaced, or displaced. Angulation of the affected hemipelvis as compared with the unaffected side was measured on the CT and inlet views. Injuries were also classified as having unilateral or bilateral rami fractures.

Results: All data are reported as percentages for the cells available so that not all results represent all cases. We enrolled 250 patients with an average age of 39 years and an average ISS of 13.9 of which 61% were female. The average BMI (body mass index) was 25.8. The most common mechanisms of injury were motor vehicle accident (50%) followed by fall from a height (23%). 60% had zone-1 sacral fractures. 26% had bilateral and 74% had unilateral rami fractures. The majority (62% AP, 63% inlet, 66% CT) of the patients had no displacement (0 mm). The anterior and posterior cortices of the sacrum were impacted or nondisplaced in 91% and 77% of cases, respectively. 171 patients were treated nonopera-

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tively and 79 operatively. There were no differences in age, gender, BMI, ISS, or mechanism of injury between the groups. The presence of bilateral versus unilateral rami, or having a displaced versus impacted anterior cortex did not correlate with surgery. Displacement on the inlet view and rotational displacements were also not different between the groups. Table #1 details the differences that were found between the operative and nonoperative groups. The major factors were having a zone 2 rather than a zone-1 injury, having posterior cortical displacement, and greater displacement on the AP radiograph and CT. However, the average displacement of those having surgery was only 2.5 mm and 2.9 mm as measured on the CT and AP radiograph. Finally, 45% of those treated surgically had zero displacement, and 72% had <5 mm of displacement.

Conclusion: We sought to evaluate the indications for operative management of unilateral sacral fractures by comparing the patient demographics and fracture location, pattern, and displacements (translational and rotational) of a prospective cohort of patients treated in 16 trauma centers. The only factors that correlated with the choice for surgery were zone 2 injury versus zone 1 and posterior cortical displacement on the CT. Most patients who were treated operatively had <5 mm of displacement of the sacrum. A large number of like patients are being treated operatively and nonoperatively by different surgeons that may lend itself to a randomized controlled trial.

Surgery for Unilateral Sacral Fractures: Are the Indications Clear?

Table #1: Differences in patients treated operatively vs nonoperatively

	Zone 1 vs 2	Posterior cortex Displaced No vs Yes	Displacement AP X-ray (mm)	Displacement CT (mm)
Operative	**24 vs 37**	**46 vs. 19**	**2.9 ± 4.2**	**2.5 ± 4.0**
Nonoperative	**92 vs 36**	**114 vs. 8**	**0.8 ± 2.2**	**0.8 ± 2.7**
P value	**< 0.0001**	**0.0001**	**<0.0001**	**0.011**

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Posterior Fixation in APC-2 Pelvic Ring Injuries Decreases the Rates of Anterior Plate Failure and Malunion

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Purpose: Biomechanical studies report that augmenting anterior pelvic ring fixation with posterior fixation significantly increases stability. While clinical studies assess radiographic outcomes following plate fixation of the anterior pelvis, no studies have purely compared the radiographic and clinical outcomes of a partially disrupted hemipelvis (intact posterior sacroiliac ligaments) treated with either anterior plate fixation alone versus anterior fixation with percutaneous posterior iliosacral screw fixation. Our aim was to determine whether anterior fixation alone is adequate to control sagittal and coronal plane rotation and prevent malunion in pelvic ring injuries with anterior sacroiliac widening.

Methods: A retrospective review of all skeletally mature patients with a traumatic pelvic disruption treated from 2004 to 2014 with anterior symphyseal plating with or without a posterior iliosacral screw was completed. Inclusion criteria included type-2 anteroposterior compression (APC-2) pelvic ring injury with CT evidence of symphyseal disruption and isolated anterior widening of one sacroiliac joint. Patients with fractures of the acetabulum, pubic rami, or sacrum were excluded, as were those with bilateral injuries. Patients were then divided into two groups: those that only underwent plating of the symphysis with a 3.5-mm 6-hole plate versus those that also had placement of a percutaneous partially threaded 7.0-mm or 7.3-mm iliosacral screw. Patients were followed for a minimum of 6 months or to failure of fixation. Examined data points included age, anterior symphyseal diastasis as measured on CT, duration of follow-up, time to fixation failure (failure defined as any change in anterior fixation visible on follow-up radiographs), type of fixation failure, and presence of malunion. Malunion was defined as >5 mm of either rotational or translational displacement of the hemipelvis and pubic symphysis in a nonanatomic position. Statistical analysis was completed using Pearson uncorrected chi-square test. P <0.05 was considered statistically significant.

Results: Complete documentation (chart and radiographic) was available on 140 patients. 96 patients underwent combined anterior and posterior fixation, and 44 patients had anterior plate fixation alone. Average age and length of follow-up was 38 years and 7.2 months, respectively. Anterior plate fixation failure occurred in 5 patients (7.3%) in the combined fixation group and in 17 patients (38.6%) in the anterior-only group (P <0.0001). Malunion was identified in one patient (1.0%) in the combined treatment group and in 15 patients (34.1%) in the anterior-only cohort (P <0.0001).

Conclusion: APC-2 pelvic ring injuries treated with anterior plating and supplemental posterior screw fixation have significantly less anterior hardware failure and malunion than those treated with anterior plating alone.

A Prospective Trial Comparing Magnetic Resonance Imaging-Detected Pelvic Ligament Injury to Displacement on Pelvic Stress Examination Under Anesthesia

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Purpose: Recently both pelvic stress examination under anesthesia (EUA) as well as pelvic magnetic resonance imaging (MRI) have been reported as means to potentially evaluate pelvic ring fracture stability. However, the relation of findings on these two tests to each other is unknown. We hypothesized that MRI-detected pelvic ligament injury pattern would correlate with findings on pelvic stress EUA.

Methods: Twenty patients with acute pelvic ring injury (OTA 6.1-A2, 6.1-A3, 6.1-B or 6.1-C) were enrolled in a prospective trial from 2013-2014. All patients underwent the study intervention of pelvic stress EUA and MRI within 14 days of injury, and were included in the analysis. IRB approval was obtained and informed consent obtained. EUA was performed according to the method of Sagi et al, with the use of a calibrated radio-opaque marking ball. Fifteen standardized fluoroscopic views were obtained and analyzed at each EUA. Maximum horizontal, vertical, and combined vector displacement was measured on each view. MRI scans were graded for ligament and pelvic floor musculature injury by three independent musckuloskeletal radiology attending physicians. Ligament injury was scored as either complete tear, partial tear, or intact. Radiologists were blinded to the side of injury. For the cases when radiologists did not agree on MRI findings, an MSK (musculoskeletal) consensus committee reviewed the MRI, with the decision of the senior MSK radiologist final. Ligament injury on MRI was correlated with various measures of displacement on pelvic EUA using Pearson correlation coefficient (two-tailed, $P < 0.05$). Interrater agreement was assessed using intraclass correlation coefficient (ICC). IBM SPSS Statistics v.20.0 was used for statistical analysis.

Results: We found no significant correlation between MRI-detected ligament injury and either horizontal, vertical, or combined vector displacement on the 15 pelvic stress EUA images. We did, however, find that contralateral ligament and pelvic floor injury injury was observed in 75% of cases while only 30% of patients were thought to have bilateral injury by CT and radiographic classification alone. We found substantial interrater agreement between radiologists. The highest agreement was observed for anterior sacroiliac ligament injury (ICC = 0.9, confidence interval: 0.83-0.95, $P < 0.0001$). External, internal, and vertical displacement on pelvic stress EUA ranged from 9 to 71 mm, 0 to 31 mm, and 5 to 79 mm, respectively, indicating the wide range of injuries in the study.

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Conclusion: In this study, MRI-detected pelvic ligament injury pattern did not correlate with stress EUA displacement. Our finding of a high rate of contralateral ligament and pelvic floor injury suggests that a higher percentage of pelvic ring fractures may be associated with bilateral ligament injuries than previously thought. Our hope was that EUA could be used to predict the findings on MRI; however, our results appear to indicate that EUA is not a good predictor of which ligaments are injured in this patient population. The clinical role of both pelvic EUA and MRI awaits further research, but our data indicate that MRI and EUA appear to measure unique aspects of pelvic ring injuries.

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.

Fixed-Angle Versus Polyaxial Locking Plate Fixation Systems for Periprosthetic and/or Osteoporotic Distal Femoral Fractures

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Background/Purpose: Contemporary fixation of distal femoral fractures, especially in the presence of poor bone stock and/or of an ipsilateral knee arthroplasty, refers to the use of precontoured locking plating systems. They have evolved to include stainless steel or titanium alloy plates, with different thickness, shapes, external targeting jigs, and reduction tools for minimal invasive surgery, multidirectional or fixed-angle locking options. We hypothesized that the use of a plating system of newer design, adopting the concept of polyaxial technology and having options of insertion of different screw designs at the metaphyseal part, is equally effective in comparison to the first generation of periarticular distal femoral locking plates.

Methods: A prospective, concealed randomized clinical trial was conducted from 2010 between 4 UK centers, with selection criteria on osteoporotic and/or periprosthetic distal femoral fractures, excluding patients with dementia, loose femoral components, preinjury impaired mobility, or associated trauma influencing ambulation. The primary objective of the study was to test the hypothesis that the Polyax-BIOMET achieves similar union rates at comparable time frames with the LISS-DePuy/SYNTHES. The secondary objectives of this study included the comparison of intraoperative details (ie, closed vs open reduction, length of incisions, duration of surgery), the comparison of radiological characteristics of the plate/bone constructs (stiffness score, plate/screw density, plate span width, working length), the comparison to the incidence of nonunion, malunion, hardware failure, complications, secondary surgery, and the functional outcome according to the Oxford knee score, and the EuroQol (EQ)-5D. All fractures were classified according to the AO/OTA system, as well as the Rorabeck system, and bone density using the Singh score. The analysis of the accumulated data was a logistic regression of union on covariates that included use of either system with variables including: age, sex, smoking, mechanism, fracture type, Singh index, timing of ambulation progress, complication rates, quality-of-life score, and knee function. Statistical significance was set to the P value <0.05.

Results: In a 1:1 ratio, 40 patients were recruited following informed consent, and completed a 12-month follow-up. The overall union rate at 6 months was 73%, at 9 months was 90%. The 4 overall nonunions led all to revision surgeries, 2 exchanging to a retrograde femoral nail, 2 by using bone grafting without revision of osteosynthesis. Malunion was evident in 2 cases, one with 17° of recurvatum and 10° valgus, and one with 10° of recurvatum. The mortality rate at 1 year was 10%. Between the 2 plating systems statistical analysis verified

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no significant differences in regards to the demographics (mean age, 78 years (range, 58-99); gender 87.5% females), the mechanism of injury (falls from standing height 87.5%), the impact of comorbidities (Charlson score mean 5 (Range, 2-9), Singh score mean 2 (range, 1-4), the ratio of periprosthetic fractures (32%), the duration of surgery (mean 86 min; range, 55-192), the surrogate length of incisions (mean 15 cm; range, 7-33 cm), the stiffness score (mean 1; range, 0-3), the percentage of filled holes (mean 50.7%; range, 33.6-88.3%), the plate span width (mean 2.35; range,1.3-4.3), the working length (mean 135 cm; range, 46-227 cm), the ratio of working length/fracture length (mean 1.56; range, 0.75-3.27), the hospital stay (21 days; range, 10-43), and the ambulatory progress, as well as functional, quality of life and pain scoring at 6, 9, and 12 months. The number of open reductions (29% vs 19%) were more in the LISS group, although more complex fractures according to the AO/OTA system were managed in the later group (22.5% LISS 33.A1 vs 77.5% LISS 33.A2/3/B/C instead of 15% vs 85% POLYAX). Another significant difference favoring the POLYAX group was the minimal medial prominence of metaphyseal screws, which occurred in just 1 case versus in 6 cases of the LISS group, and led to secondary surgery in 3 of them.

Conclusion: The primary hypothesis was verified, with very good union rates for both systems, and limited implant-related complications. Good reduction, mechanically sound construct, and respect of the local fracture biology appears to be more important than the particular plate characteristics. The new generation of locking plates offer versatility, better use of locking corridors in poor bone stock, less screw-related soft-tissue impingement, and a short learning curve.

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∆ The Effect of Knee Flexion Contracture on Outcomes of Distal Femur Fractures

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Background/Purpose: Injuries about the knee may result in stiffness. The development of a flexion contracture is common after distal femur fracture, yet the effect of a flexion contracture on outcomes has never been evaluated. The purpose of this study is to compare the demographics and validated outcomes of patients with and without a flexion contracture after operative treatment for distal femur fractures.

Methods: As part of a multicenter randomized trial of adult patients with A1-3 or C1 (undisplaced joint injuries) distal femur fractures, data on contractures were gathered prospectively. Patients were treated by intramedullary (IM) nail or locked plate. Demographic data, ambulatory ability, and validated outcomes including SMFA (Short Musculoskeletal Function Assessment), Bother Index, and EQ health index were obtained at 3,6, and 12 months postoperatively. Range of motion was tested at each interval. Flexion contractures were defined by a lack of full extension and were documented in degrees. A contracture was defined as 10° to account for measurement variation and be certain that a noticeable

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contracture was present. Comparisons were made using a Fisher exact test for categorical variables and t tests for continuous variables.

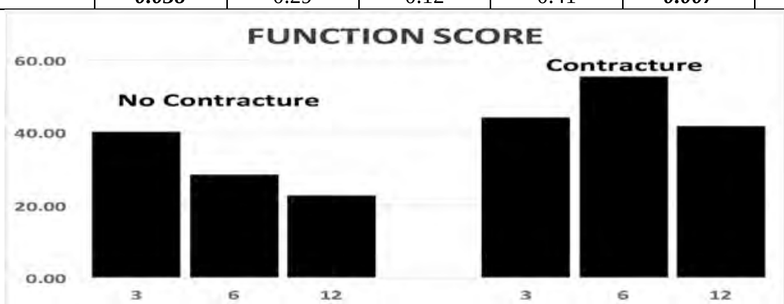
Results: 126 patients were enrolled and followed for >6 months. Of these, 98 were examined for contracture in person and had data at 3 months, 88 at 6 months, and 73 at 1 year. Patients who filled out outcome forms but were not examined in person were excluded. There were 55 men and 43 women aged 16 to 90 years (mean 51). The average ISS was 12.6 (range, 9-43) and 24 (24%) were open. A flexion contracture of 10° was present in 16% at 3 months and 14% at 1 year. Patients did not show improvement between 3 months and 1 year. There was no difference in contracture development between patients treated with nails versus plates (P = 1), open versus closed fractures (P = 0.24), or by gender (P = 0.5). Patients who developed a contracture were slightly older than those who did not, 65 ± 14 versus 52 ± 19 (P = 0.01). Outcome data are summarized in the table. Patients without a contracture had better outcomes; the SMFA score, walking distance, and stair climbing all reached statistical significance. Patients with contracture could walk less than 5 blocks and those without could walk more than 10 or were unlimited. Flexion contracture was not associated with a difference in flexion at any time point. Finally, patients with a flexion contracture did not show improvement in their SMFA score over time while those without a contracture showed steady improvement (bar graph: 3,6, and 12 months).

Conclusion: Flexion contracture after distal femur fracture occurs in approximately 15% of patients, is typically present by 3 months, and does not improve by 1 year. Outcomes for patients with contractures are worse than in those without contractures and minimal improvement is seen over the first year. Walking and stair climbing are substantially diminished.

The Effect of Knee Flexion Contracture on Outcomes of Distal Femur Fractures

One Year Results

Group	SMFA	Bother Index	EQ-Health State	Avg. Flexion	Walking (1 – 6) 1 best	Stairs (1 – 5) 1 best
Contracture	41.8	35.8	0.6	107°	4.1	3.4
No Contracture	22.8	25.1	0.8	118°	2.6	2.4
P value	***0.038***	0.29	0.12	0.41	***0.007***	***0.017***



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Malalignment After Minimally Invasive Plate Osteosynthesis in Distal Femoral Fractures

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Background/Purpose: Minimally invasive plate osteosynthesis (MIPO) is a preferred operative treatment for distal femoral fractures. Although it has the advantage of excellent bony union, malalignment is a significant concern because of the indirect reduction of the fracture. The purpose of this study was to evaluate radiologic alignment after MIPO for distal femoral fractures.

Methods: Of 138 patients with unilateral distal femoral fractures who underwent MIPO in our hospital from 2005 to 2013, we enrolled 52 patients in whom bilateral rotational alignment could be assessed by CT. The patients included 32 men and 20 women, with a mean age of 53.4 years. Thirteen patients had femoral shaft fractures (according to the AO-OTA classification: 32-A, n = 2; 32-B, n = 6; 32-C, n = 5), whereas 39 patients had distal femoral fractures (33-A, n = 7; 33-C, n = 32). Coronal and sagittal alignments were assessed by using simple radiography, whereas rotational alignment was assessed by using CT. According to the difference between the affected and unaffected side, we divided the patients into 4 groups: excellent, good, fair, and poor. Thereafter, we determined which factors can lead to malalignment, including fracture location (distal femoral shaft fracture or metaphyseal fracture), fracture pattern (simple fracture, n = 15; complex fractures, n = 37 patients), coronal and sagittal alignment, and the presence of combined ipsilateral long bone fractures.

Results: Coronal and sagittal alignment were satisfactory in 96.2% (average 2.8°, 0.2°-10.3°) and 98% (average 2.2°, 0-8.1°) of the subjects, respectively, whereas the rotational alignment was satisfactory in 57.7% of patients. The leg length discrepancy was satisfactory in 92.3% of the patients (average 10.9 mm, -9 to 112 mm). Concerning rotational malalignment, an unsatisfactory result was obtained in 48.6% of subjects with complex fractures and 26.7% of subjects with simple fractures (P = 0.114, Pearson's chi-square test). No significant correlation was noted between the angular deformity in the coronal and sagittal planes and the degree of rotational alignment (P = 0.691, multiple regression analysis). Even if good alignment of the coronal and sagittal planes achieved after surgery, this does not guarantee good postoperative rotational alignment.

Conclusion: Regardless of the fracture pattern, rotational malalignment may develop at an extremely high rate after MIPO for distal femoral fractures, whereas a satisfactory alignment is obtained concerning coronal and sagittal alignment. Extreme caution should be taken to avoid rotational malalignment using this technique.

See pages 47 - 108 for financial disclosure information.

Trochanteric Entry Femoral Nails Yield Better Postoperative Femoral Version and Lower Revision Rates than Retrograde and Piriformis Entry Nails: A Large Cohort Multivariate Regression Analysis

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Purpose: Intramedullary nailing (IMN) has become the standard of care for the treatment of most femoral shaft fractures. Different IMN options include trochanteric and piriformis entry as well as retrograde nails, which may result in varying degrees of femoral rotation. The objective of this study was to analyze postoperative femoral version between the three types of nails and to perform a regression analysis controlling for any potential confounding factors to delineate any significant differences in femoral version and revision rates.

Methods: 417 consecutive patients with femur fractures were treated with an IM nail at a Level I trauma and tertiary referral center. Of these patients, 316 met inclusion criteria and obtained postoperative CT scanograms to calculate femoral version and were thus included in the study. In this study, our main outcome measure was the difference in femoral version (DFV) between the uninjured limb and the injured limb. Femoral version was determined on postoperative CT scanograms by a trauma fellowship-trained orthopaedic surgeon. Statistical analysis included initial univariate regression followed by forward, stepwise multivariate regression analysis to compare DFV. Covariables included gender, age, body mass index (BMI), ethnicity, mechanism of injury, operative side, and open fracture.

Results: Total number included for analysis included 316 patients. Piriformis entry nails made up the majority (n = 141), followed by retrograde (n = 108), then trochanteric entry nails (n = 67). Univariate regression analysis revealed that a lower BMI was significantly associated with a lower DFV (P = 0.006). Controlling for possible covariables, multivariate analysis yielded a significantly lower DFV for trochanteric entry nails than piriformis or retrograde nails (7.9° ± 6.10° vs 9.5° ± 7.4° vs 9.4° ± 7.8°, P <0.05). Using revision as an end point, trochanteric entry nails also had a significantly lower revision rate, even when controlling for all other variables (P <0.05).

Conclusion: Comparative, objective comparisons of DFV between different nails based on entry point revealed that trochanteric nails had a significantly lower DFV and a lower revision rate, even after regression analysis. However, this is not to state that the other nail types exhibited abnormal DFV. Translation to the clinical impact of a few degrees of DFV is also unknown. Future studies of more in-depth study of the intricacies of femoral version may lead to improved technology in addition to potentially improved clinical outcomes.

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Tables

Table 1. Cohort demographic and injury data (n=316)

Parameter	Value
Mean Age (SD), yrs	31.1 (13.6)
Gender (%)	
Male	261 (82.6)
Female	55 (17.4)
Mean BMI (SD)	27.2 (5.2)
Ethnicity (%)	
Black	181 (57.3)
White	65 (20.6)
Hispanic	59 (18.7)
Asian	1 (0.3)
Other	10 (3.2)
Injury Side (%)	
Left	144 (45.6)
Right	172 (54.4)
Mechanism of Injury (%)	
MVA	133 (42.1)
GSW	64 (20.3)
Pedestrian Struck	39 (12.3)
Fall	34 (10.8)
MCA	33 (10.4)
Crush	9 (2.8)
Assault	4 (1.3)
Open Fx (%)	43 (13.6)

See pages 47 - 108 for financial disclosure information.

Table 2. Mean DFV for piriformis, trochanteric and retrograde femoral IMN along with univariate regression analysis results identifying any significant factors for each corresponding femoral IMN with lower and upper bound CI (95%). No significant impact was noted for any of the variables on mean DFV on any of the nails except a significantly correlated DFV with BMI in trochanteric start nails.

Nail Type	**Mean DFV, Degrees (SD)**	**Variable**	**p value**	**95% CI Lower Bound**	**95% CI Upper Bound**
Piriformis		**Gender**	0.48	-2.51	5.28
n=141	9.5 (7.4)	**Age**	0.83	-0.09	0.12
		BMI	0.78	-0.35	0.26
		Ethnicity	0.50	-2.05	1.00
		Mechanism of Injury	0.51	-0.48	0.96
		Operative Side	0.70	-2.17	3.22
		Open Fx	0.68	-3.30	5.02
Trochanteric		**Gender**	0.12	-8.75	0.99
n=67	7.9 (6.1)	**Age**	0.16	-0.037	0.23
		BMI*	***0.006***	***-0.94***	***-0.16***
		Ethnicity	0.27	-2.73	0.77
		Mechanism of Injury	0.08	-0.11	1.64
		Operative Side	0.80	-2.69	3.46
		Open Fx	0.18	-1.64	8.45
Retrograde		**Gender**	0.051	-0.03	8.57
n=108	9.4 (7.8)	**Age**	0.18	-0.05	0.25
		BMI	0.79	-0.35	0.46
		Ethnicity	0.35	-0.91	2.54
		Mechanism of Injury	0.80	-0.78	1.01
		Operative Side	0.42	-1.92	4.61
		Open Fx	0.53	-6.18	3.19

$^*p<0.05$

Table 3. Multivariate regression comparison of mean DFV between piriformis entry, trochanteric entry, vs retrograde femoral nails controlling for gender, age, BMI, ethnicity, mechanism of injury, operative side, and open fracture.Trochanteric entry nails had significantly lower mean DFV than piriformis start and retrograde nails.

Nail Type	Mean DFV, Degrees (SD)
Piriformis (n=141)	9.5 (7.4)
Trochanteric (n=67)	7.9 (6.1)*
Retrograde (n=108)	9.4 (7.8)

***p<0.05**

Table 4. Trochanteric entry nails had a significantly lower rate of revision than piriformis entry and retrograde nails, however, this significant difference becomes close, but not significant when analyzing via ordinal regression analysis controlling for gender, age, BMI, ethnicity, mechanism of injury, operative side, open fracture and entry point. Significant negative predictors for revision included associated open fracture.

				95% CI	
		Variable	**p value**	**Lower Bound**	**Upper Bound**
Revision[γ] (%)	**n (%)**	**Gender**	0.53	-1.17	2.27
No	304 (96.2%)	**Age**	0.27	-0.10	0.03
Yes	12 (3.8%)	**BMI**	0.76	-0.10	0.13
Piriformis	9 (75%)	**Ethnicity**	0.38	-1.31	0.50
Trochanteric	**0 (0%)***	**Mechanism of Injury**	0.25	-0.13	0.51
Retrograde	3 (25%)	**Operative Side**	0.97	-1.20	1.25
		Open Fx**	**0.03**	**-2.82**	**-0.11**
		Nail Entry	0.05	-1.61	0.01

[γ]Revision was defined as reoperation. All piriformis revisions were indicated for clinically significant malrotation; 2/3 retrograde nails were revised for malrotation, the other for non-union requiring an exchange nail.
*p=0.005 via chi-square analysis.
**p<0.05 via ordinal regression analysis.

Table 5. Subgroup analysis of IMN revisions secondary to malrotation

Nail Type	Piriformis (n=9)	Retrograde (n=2)
Mean DFV (SD)	21.9 (7.8)	19.1 (22.2)
Number Proximal Fragment Malrotation (%)	3 (33)	0 (0)
Number Distal Fragment Malrotation (%)	5 (56%)	1 (50)
Number Both Fragment Malrotation (%)	1 (11)	1 (50)

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Sagittal Femoral Bow Is Dependent on Bone Density

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Background/Purpose: Despite implant modifications to better match the sagittal bow of the femur, anterior cortical perforation and abutment remain prevalent with intramedullary nail fixation of proximal femur fractures. Prior femoral bow analyses have demonstrated an association between femoral bow, gender, age, and length but none with bone density. We tested the hypothesis that femoral bow is dependent on bone density.

Methods: 167 patients with a positron emission CT scan and a DXA (dual xray absorptiometry) scan within 1 year of each other were analyzed. The sagittal radii of curvature (ROCs) of the outer and inner anterior cortical boundaries of the femur were determined with a novel custom MATLAB script. Associations between age, gender, femoral length, World Health Organization (WHO) T-score class, and femoral ROC were determined with regression analyses.

Results: Study included 138 females and 29 males, mean age 59 years (standard deviation [SD] = 15). Mean femur length was 42.7 cm (SD = 27.0). Average time between CT and DXA was 174 days (SD = 108). Mean outer and inner anterior ROCs were 149.5 cm (SD = 56.7) and 147.5 cm (SD = 54.4), respectively. 68, 81, and 18 patients had normal, osteopenic or osteoporotic hips, respectively, while 79, 60, and 23 had normal, osteopenic or osteoporotic lumbar spines, respectively. Five lumbar spines were too degenerative for bone density assessment. The ROC of the outer, but not the inner, anterior cortical boundary of the femur depended on WHO bone density classification at the hip (P = 0.034 for outer, P = 0.114 for inner). Femoral ROC was not dependent on lumbar spine bone density. In addition to bone density, femoral length was associated with ROC (P = 0.015 for outer, P = 0.049 for inner) while age and gender were not.

Conclusion: The sagittal bow of the femur depends on bone density. Caution should be taken during guide wire introduction, reaming, and intramedullary nail insertion in low radii of curvature femurs due to their low bone density, or alternative treatment options should be considered.

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.

Immediate Weight Bearing as Tolerated has Improved Outcomes Compared to Non-Weight Bearing after Intramedullary Fixation for Subtrochanteric Fractures

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Background/Purpose: Subtrochanteric femur fractures are commonly managed with operative fixation; however, they have a high complication rate including malunion, nonunion, and implant failure because of cortical comminution and stress concentration during stance. While the angled blade plate has been the gold standard for treatment, the last decade has seen a rise in the use of intramedullary fixation with new biomechanical data. Previous studies demonstrated satisfactory outcomes with a soft-tissue-friendly approach and avoiding varus malreduction; however, these studies utilized protected weight bearing for 6 to 8 weeks. The literature clearly demonstrates the benefit of early weight bearing in trauma patients and the safety of statically locked intramedullary nails in highly comminuted femoral shaft fractures. The literature has limited data to support immediate postoperative weight bearing after intramedullary fixation of subtrochanteric femur fractures. Our hypothesis was that immediate postoperative weight bearing as tolerated (WBAT) for subtrochanteric femur fractures would result in decrease length of stay (LOS) compared to non-weight bearing (NWB).

Methods: After IRB approval a retrospective cohort study was conducted from August 2009 to November 2015 at two Level I trauma centers. Inclusion criteria were skeletally mature patients with a subtrochanteric femur fracture (OTA 31A3.3 and 32A1.1-32A3.3). Exclusion criteria was presentation GCS (Glasgow Coma Scale) below 8, orthopaedic injury affecting weight bearing, thoracic or abdominal injury requiring surgery, periprosthetic fracture, and bisphosphonate-related atypical subtrochanteric femoral fractures. 69 patients met the inclusion criteria and underwent intramedullary fixation. These cohorts were compared using Wilcoxon rank sum test for statistical significance. Patients were evaluated regarding age, sex, mechanism of injury, implant type, implant size, degree of comminution, and fracture type. Primary outcome was total LOS, with subgroup analysis of high-energy cohort.

Results: The mean patient age was 55.7 years (range, 19-95) with a bimodal distribution of 36.5 (range, 19-66) and 73.4 (range, 59-95) for high and low-energy, respectively. Implant choice was predominantly cephalomedullary nail (83%, n = 57), followed by reconstruction (13%, n = 9) and standard piriformis entry (4%, n = 3). The nail diameter was predominantly 10 mm (75%, n = 52) followed by 11.5 mm (13%, n = 9). Overall the WBAT group had a decreased LOS compared to the NWB group (5.9 vs 4.5, P = 0.01). While the high-energy group had a longer overall LOS compared to the low-energy group (5.3 vs 4.4, P = 0.01),

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a subgroup analysis of high-energy patients with highly comminuted fracture patterns (Winquist-Hansen grade 3 or 4) had a decreased LOS when allowed WBAT as compared to NWB (5.1 vs. 7.0, P = 0.01). There was no statistical difference in the union rates or implant failures between groups.

Conclusion: This study demonstrates that immediate postoperative weight bearing of subtrochanteric femur fractures decreased length of stay and does not appear to increase the risk of implant failure or nonunion. Our data also suggest that in a high-energy cohort with highly comminuted subtrochanteric fracture patterns, immediate WBAT protocol may lead to decreased LOS and has similar safety with implant sizes of 10 mm. We plan to continue studying the effect of early WBAT on subtrochanteric fractures and the effect on patient-reported outcomes.

∆ Do We Really Understand the Patient Populations in Database Research: A Comparison of Femoral Shaft Fracture Patients in Three Commonly Used National Databases

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Purpose: Use of national databases has increased dramatically in the field of orthopaedics and orthopaedic traumatology. However, with the multitude of databases now being used to draw clinical conclusions, there has been little study of the differences in populations contained in various databases. The aim of the current study is to compare the populations of patients with femoral shaft fractures, a common high-energy orthopaedic injury, in three commonly used national clinical databases, in terms of age, comorbidities, and adverse events.

Methods: Patients with surgically managed femoral shaft fractures were identified in the Nationwide Inpatient Sample (NIS), National Surgical Quality Improvement Program (NSQIP), and National Trauma Data Bank (NTDB). Age, Charlson comorbidity index (CCI), individual comorbidities, and inpatient adverse events were compared between databases.

Results: The distributions of age (Figure) and CCI suggest a predominantly older population with more preexisting comorbidities in NSQIP (age [mean ± standard deviation] = 71.5 ± 15.6, CCI = 4.9 ± 1.9), and a younger population with fewer preexisting comorbidities in NTDB (age = 45.2 ± 21.4, CCI = 2.1 ± 2.0). Bimodal distributions in the NIS population suggest it includes a more mixed population (age = 56.9 ± 24.9, CCI = 3.2 ± 2.3). Differences in age and CCI were all statistically significant (P <0.001). Differences in outcomes were also observed in the different database populations. In fact, the rate of adverse events varied from 21.6% in NIS to 9.1% in NSQIP (P <0.001). Further, the rate of serious adverse events (death, cardiac arrest, myocardial infarction, stroke, thromboembolic event, or surgical site infection) varied from NTDB (7.4%) to NIS (5.1%); P <0.001. Considering individual adverse events, the rate of thromboembolic events ranged from 4.2% in NTDB to 1.1% in NSQIP (P <0.001). The rate of pneumonia ranged from 4.3% in NTDB to 1.5% in NSQIP (P <0.001). The rate of urinary tract infection ranged from 12.1% in NIS to 2.8% in NTDB (P <0.001).

Conclusion: Differences in populations contained in commonly used national databases are not always readily apparent. Care must be taken to fully understand these populations before performing or evaluating database research, as these differences clearly affect observed outcomes.

∆ OTA Grant

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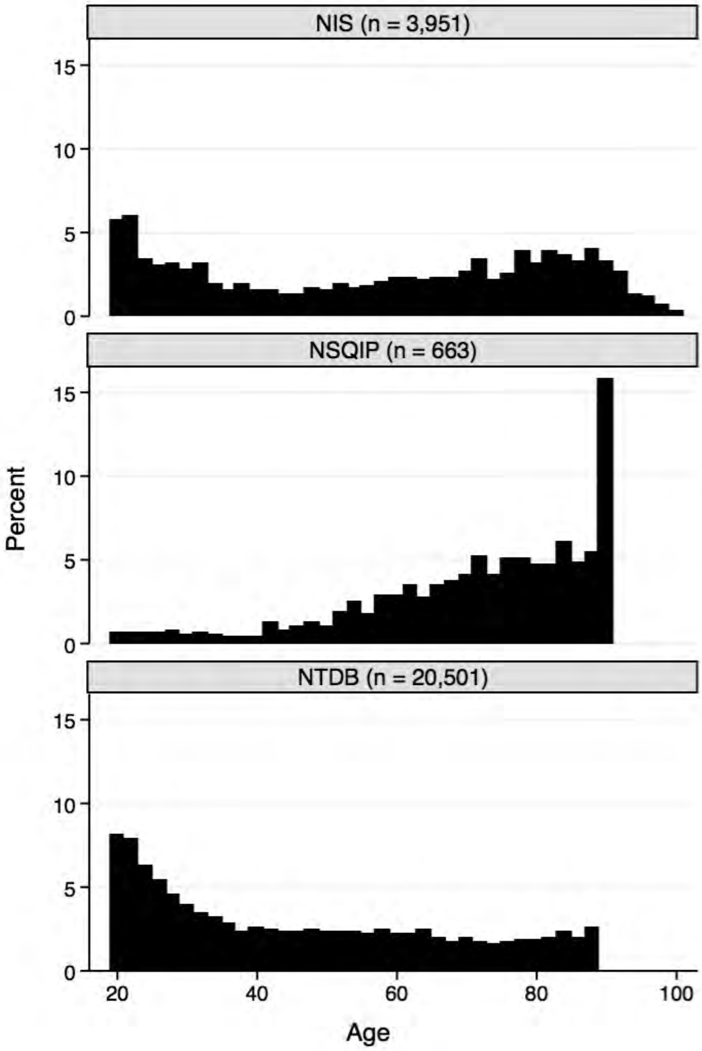

PAPER ABSTRACTS

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.

Patient-Specific Injury Profiles Predict Organ Failure in Multiply Injured Patients

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Background/Purpose: Multiply injured patients (MIPs) sustain a composite of mechanical tissue damage, ischemic tissue damage, and hemorrhage-associated hypoperfusion that is specific to the individual injury. Metabolic response to injury is also highly variable and patient-specific. Collectively, individual injury and response characteristics affect complications and outcomes. While some MIPs demonstrate an uneventful recovery, other MIPs with seemingly similar injuries develop complicated clinical courses punctuated by wound problems (coagulopathy, infection, poor wound healing), systemic inflammatory response syndrome (SIRS), multiple organ failure (MOF), and death. Early identification of MIPs at risk for complicated clinical trajectories remains a diagnostic challenge. Current injury scoring systems are granular and do not account for patient-specific injury characteristics. In addition, these systems do not quantify patient response. They are of limited value in stratifying clinical trajectories and guiding treatment, including subsequent orthopaedic interventions. In this study, we explore a new paradigm by quantifying early (within 48 hours of trauma) individualized critical components of injury including mechanical tissue damage, magnitude and duration of shock, and acute metabolic response to establish a Patient-Specific Injury (PSI) score. We hypothesized that PSI scores would accurately stratify patient risk for MOF.

Methods: 72 consecutive adult (18-65 years) MIPs (ISS >18) admitted to the intensive care unit (ICU) for a minimum of 7 days were studied retrospectively. We collected vital signs and laboratory values during ICU admission, and accessed all admission imaging studies. Total body patient-specific mechanical tissue damage was quantified using a novel index (Tissue Damage Volume Score [TDVS]). TDVS calculates a volume (cm3) of every injury sustained by a patient based on measurements made from admission CT scans and radiographs. Total body TDVS was subdivided by tissue type and body region (head/neck, chest, abdomen, pelvis, extremities). Hypoperfusion was calculated by integrating elevated values of shock index (SI) (SI = heart rate/systolic blood pressure; SI >0.9 is a validated marker of hypoperfusion) over time to yield a patient-specific metric termed Shock Volume (SV). Patient-specific metabolic response was measured by calculating the difference of mean pH for the first 48 hours after injury from normal (7.40). TDVS, SV, and pH deviation were integrated into a PSI score. PSI scores were compared to Sequential Organ Failure Assessment (SOFA) scores with linear regression to determine correlation between PSI profiles and organ failure. The SOFA score is a validated outcome instrument that measures organ failure in trauma patients and was utilized as the primary outcome in this study.

Results: Total body PSI scores (Figure 1a) correlated well with organ dysfunction over the entire population. Pelvic PSI scores (Figure 1b) and abdominal PSI scores (Figure 1c) correlated more closely with organ dysfunction. Chest PSI scores corresponded to organ dysfunction, but the variability was greater (Figure 1d). There was minimal correlation between extremity and head/neck PSI scores and organ dysfunction (not shown).

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Conclusion: It has been postulated that the magnitude of mechanical and ischemic tissue injury and resuscitation dictate patient response and orchestrate clinical trajectories in MIPs. Our data demonstrated that patient-specific indices measured early during the injury period (mechanical tissue damage, hypoperfusion, metabolic response) collectively predicted subsequent organ dysfunction on an individual basis. PSI scores in patients sustaining axial trauma (chest, abdomen, and pelvis) were more accurate in predicting subsequent organ dysfunction. Such information could prove to be clinically relevant in timing interventions, including major orthopaedic operations. Although preliminary, this research offers a novel approach of applying personalized medicine to trauma patients.

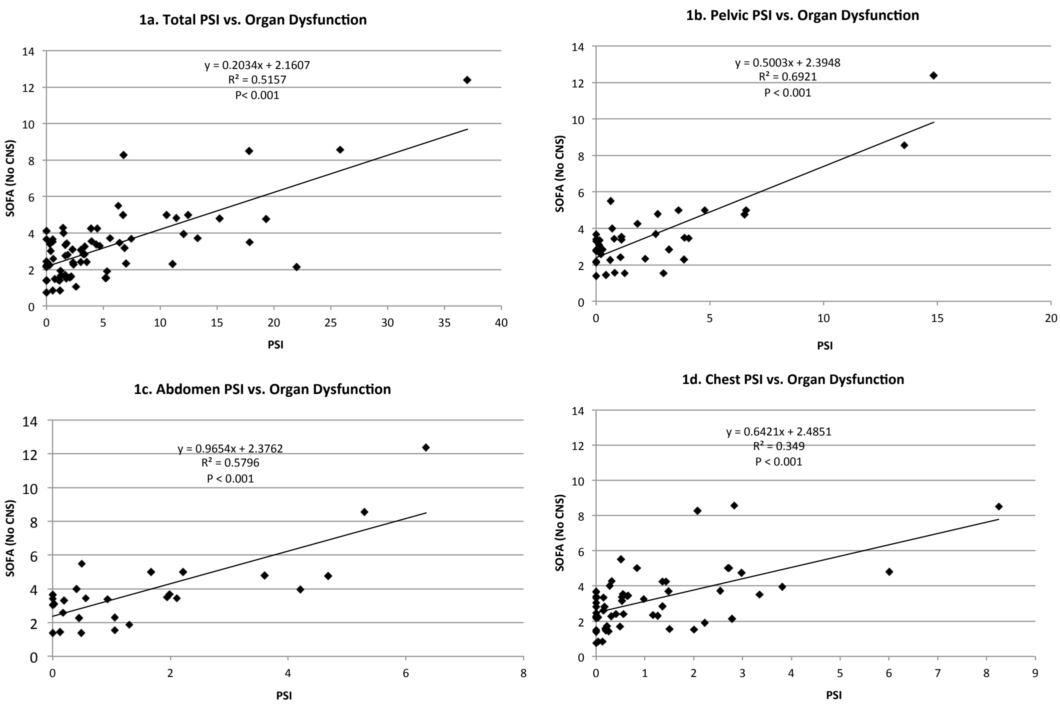

Figure 1: PSI Scores vs. organ dysfunction. Organ dysfunction was measured by SOFA scores. The CNS component was purposefully omitted from SOFA scores to improve clinical accuracy in an ICU patient population. Organ dysfunction correlated to PSI scores calculated from total body TDVS (Fig 1a), pelvis TDVS (Fig 1b), abdominal TDVS (Fig 1c), and chest TDVS (Fig 1d). PSI was most predictive of organ dysfunction in patients sustaining pelvic (R^2 = 0.69) and abdominal trauma (R^2 = 0.58).

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Limb Salvage Versus Transtibial Amputation: A Comparison of Functional Gait Outcomes

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Background/Purpose: Several studies have compared outcomes of transtibial amputation patients and limb salvage patients with no clear advantage evident. With recent military conflicts resulting in significant numbers of lower extremity injuries, this debate has again come to the forefront. The recently developed Intrepid Dynamic Exoskeleton Orthosis (IDEO) has been shown to have superior functional results to other orthoses used with limb salvage. The purpose of this study is to determine if there is a difference in functional gait outcomes between patients with isolated traumatic below-knee single limb injuries treated with either a transtibial amputation or who use an IDEO and have undergone limb salvage procedures.

Methods: 24 IDEO and 99 transtibial amputation patients were studied in our instrumented gait lab from 2007 to 2014. Transtibial amputation patients with a gait study completed between 6 months and 1 year after walking without assistive devices were included, while IDEO patients were included if they had completed the "Return to Run" training program. Ten patients with amputations were matched by body mass index to the ten limb salvage patients. These two groups were then compared in regards to demographics and injury characteristics. Three-dimensional gait analysis data were collected with a 12-camera Motion Analysis Corporation system. Temporal spatial, kinetic (vertical ground reaction force), unified deformable (UD) power, work, and efficiency during walking at a self-selected speed were evaluated. A paired t test of the differences was utilized for statistical analysis.

Results: There were no significant differences between IDEO and amputation patients in regard to demographics or injury characteristics. IDEO patients walked with a significantly slower cadence (P = 0.036), spent less time on their affected limb in stance (P = 0.045), and more time in swing (P = 0.019) compared to transtibial amputation patients. Transtibial amputation patients and IDEO patients did not have significantly different vertical ground reaction forces. Transtibial amputation patients had significantly increased maximum positive power in the affected (P = 0.004) and unaffected (P = 0.029) limbs along with increased maximum negative power on the unaffected limb (P = 0.035) compared to the IDEO patients. There was significantly increased positive and negative work in the affected limb of amputation patients (P = 0.0009 and P = 0.014) and positive work in the unaffected limb (P = 0.042). There was no significant difference in the efficiency between the groups in either the affected or unaffected limb (P = 0.174).

Conclusion: Analysis of temporal spatial gait data showed statistically significant decreases in cadence, as well as diminished stance and increased swing times on the affected limb, consistent with a more antalgic gait pattern in IDEO patients. The UD power analysis demonstrated a more dynamic gait in transtibial amputation patients, with minimum and maximum peak values more closely resembling that of normative data. Thus in our sample of ten matched patients, those with a prosthesis had more dynamic functional outcomes compared to IDEO patients.

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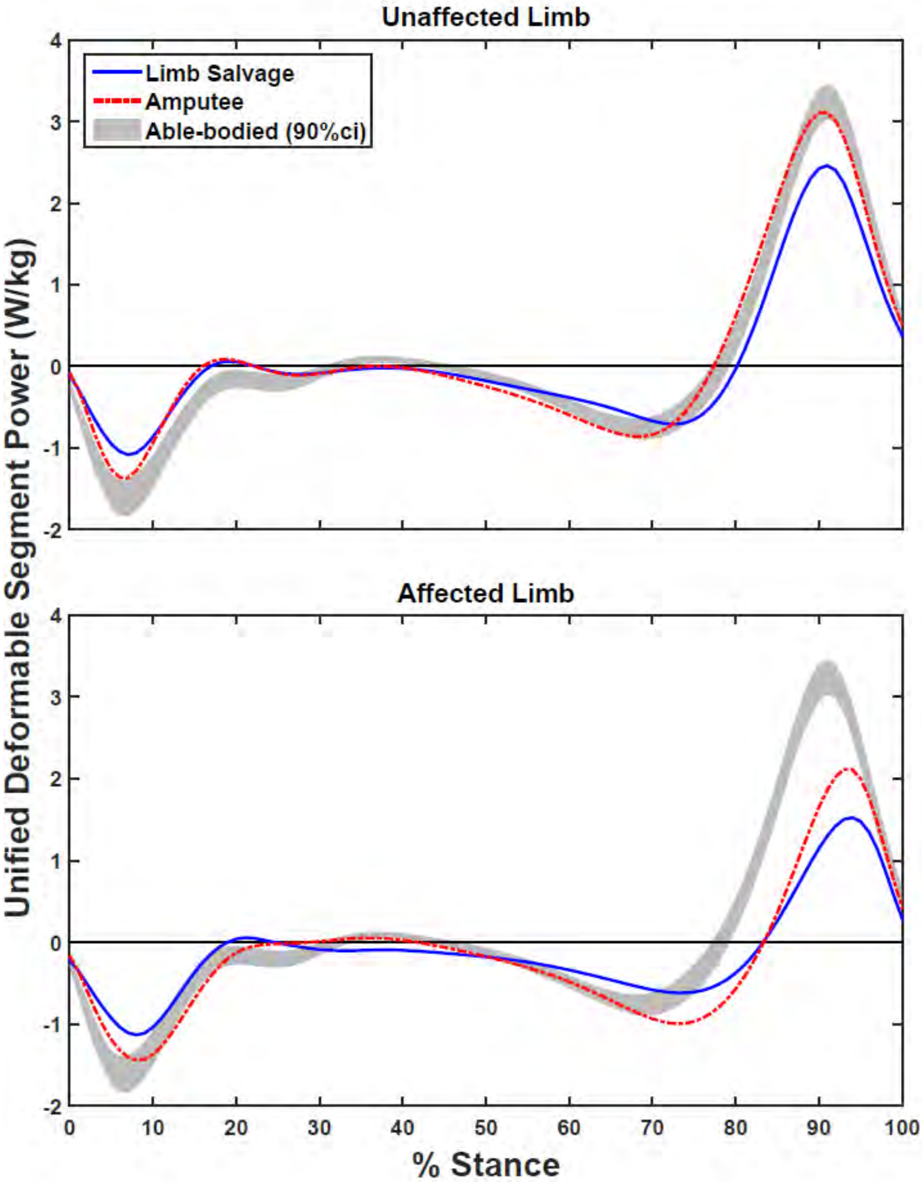

The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

Table 1. Temporal spatial gait parameters.

Parameter	Limb Salvage	Transtibial Amputation	*P*
Velocity (cm/sec)	1.26 ± 0.16	1.36 ± 0.10	0.071
Cadence (steps/sec)	104.72 ± 4.76	110.44 ± 6.86	**0.036**
Stride width (cm)	0.13 ± 0.03	0.12 ± 0.03	0.514
Stance time Aff (% gait cycle)	0.60 ± 0.01	0.61 ± 0.01	**0.045**
Stance time Un(% gait cycle)	0.63 ± 0.01	0.64 ± 0.02	0.696
Swing time Aff (% gait cycle)	0.40 ± 0.01	0.39 ± 0.01	**0.019**
Swing time Un (% gait cycle)	0.37 ± 0.01	0.37 ± 0.02	0.854
Stride length Aff (cm)	1.44 ± 0.14	1.48 ± 0.09	0.457
Stride length Un (cm)	1.44 ± 0.13	1.49 ± 0.09	0.340
Step length Aff (cm)	0.72 ± 0.07	0.76 ± 0.05	0.172
Step length Un (cm)	0.72 ± 0.07	0.72 ± 0.04	0.894

Aff: affected extremity, Un: unaffected extremity.

Table 2.Unified deformable segment power generation.

Segment power (W/kg)	Limb Salvage	Transtibial Amputation	*P*
Aff Max Positive	1.53 ± 0.38	2.14 ± 0.41	**0.004**
Un Max Positive	2.49 ± 0.53	3.21 ± 0.54	**0.029**
Aff Max Neg MS	-1.16 ± 0.37	-1.49 ± 0.55	0.128
Un Max Neg MS	-1.10 ± 0.31	-1.51 ± 0.59	**0.035**
Aff Max Neg LS	-0.64 ± 0.39	-1.04 ± 0.20	**0.005**
Un Max Neg LS	-0.77 ± 0.22	-0.90 ± 0.10	0.181

Aff: affected extremity, Un: unaffected extremity, Neg: negative, MS: mid-stance, LS: late stance.

Increasing Severity of the Orthopaedic Trauma Association Open Fracture Classification (OTA-OFC) Correlates with Increasing Amputation Rate: A Prospective Multicenter Study

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Purpose: Open fractures are common and present unique challenges to orthopaedic surgeons. Most treatment decisions are based upon surgeon experience, estimated Gustilo-Anderson classification, and regional preferences. While widely used to describe open fractures in present practice, the Gustilo-Anderson system has demonstrated multiple flaws and was not originally described to be of prognostic use. The OTA Open Fracture Classification (OTA-OFC) represents a comprehensive classification system intended to be objectively obtained and of prognostic value. The OTA-OFC is a 3-level, 5-subclassification system that describes skin injury, muscle injury, arterial injury, bone loss, and contamination. The present study reports its utility in clinical practice and assesses its ability to guide treatment decisions and predict short-term outcomes at multiple centers.

Methods: After IRB approval, a prospective multicenter observational study was undertaken. Patient age, AO-OTA fracture classification, OTA-OFC, number of operative debridements, wound vac (vacuum-assisted closure) use, and antibiotic bead use were all recorded. Primary outcomes of amputation, infection requiring antibiotics, and wound healing were all recorded. A minimum of 90 days follow-up was required for study inclusion. Descriptive statistics were used to describe the study population. Logistic regression using forward conditional analysis was used to predict the impact of the OTA-OFC on short-term outcomes. All analysis was done using SPSS v21.

Results: 419 fractures in 373 patients across 10 trauma centers were enrolled in the study with minimum follow-up of 90 days. Of these fractures, 31 required amputation (7%), 101 developed infections necessitating IV antibiotics (24%) and excluding patients who went on to amputation for wound healing problems, 55 had not healed their wounds of compounding at the time of their 90-day follow-up appointment (13%). Logistic regression to predict amputation demonstrated that arterial and skin injury were statistically significant contributors to the prediction of amputation. Bone injury and muscle damage were significant contributors to the prediction of readmission for IV antibiotics. The OTA-OFC did not show correlation with wound healing at 90 days.

Conclusion: The OTA-OFC was designed as an objectively obtainable descriptive system that can be used at multiple locations with good interobserver reliability. It has been shown to have good prognostic value at one treatment center. The goal of this study was to determine its utility in clinical practice and to assess its ability to guide treatment decisions and predict short-term outcomes at multiple centers. The present data demonstrated that arterial and skin injury were statistically significant contributors to the prediction of amputation. Bone injury and muscle damage were significant contributors to the prediction of readmission

for IV antibiotics. The OTA-OFC did not show correlation with wound healing at 90 days. This study demonstrates the value of the OTA-OFC as a classification tool at multiple centers in modern practice, and is another step in the use of this system to guide open fracture management decisions.

		Skin			Total	
		1- edges approximate	2- edges do not approximate	3- extensive degloving		P Value
Amputation	No	274	45	34	353	
	Yes	2 (0.7%)	4 (8.2%)	25 (42.4%)	31	
Total		276	49	59	384	.000
		Muscle			Total	
		1- no necrosis	2-necrosis with intact unit	3- disruption of muscle-tendon unit		
Amputation	No	208	133	12	353	
	Yes	2 (1%)	12 (8.3%)	17 (58.6%)	31	
Total		210	145	29	384	.000
		Artery			Total	
		1- no major injury	2-injury with no ischemia	3- distal ischemia		
Amputation	No	332	15	6	353	
	Yes	9 (2.6%)	8 (34.8%)	14 (70%)	31	
Total		341	23	20	384	.000
		Contamination			Total	
		1- none	2- surface only	3- deep		
Amputation	No	233	83	37	353	
	Yes	7 (2.9%)	8 (8.8%)	16 (30.2%)	31	
Total		240	91	53	384	.000
		Bone Loss			Total	
		1- none	2- loss with cortical contact	3- segment loss		
Amputation	No	224	114	15	353	
	Yes	6 (2.6%)	10 (8.1%)	15 (50%)	31	
Total		230	124	30	384	.000
		Skin			Total	
		1	2	3		P value
Antibiotics	No	230	30	32	292	
	Yes	44 (16.1%)	19 (38.8%)	27 (45.8%)	90	
Total		274	49	59	382	.000
		Muscle			Total	
		1	2	3		
Antibiotics	No	185	89	18	292	
	Yes	24 (11.5%)	55 (38.2%)	11 (37.9%)	90	
Total		209	144	29	382	.000
		Artery			Total	
		1	2	3		
Antibiotics	No	267	12	13	292	
	Yes	72 (21.2%)	11 (47.8%)	7 (35%)	90	
Total		339	23	20	382	.007
		Contamination			Total	
		1	2	3		
Antibiotics	No	189	73	30	292	
	Yes	49 (20.6%)	18 (19.8%)	23 (43.4%)	90	
Total		238	91	53	382	.001
		Bone Loss			Total	
		1	2	3		
Antibiotics	No	199	75	18	292	
	Yes	29 (12.7%)	49 (39.5%)	12 (40%)	90	
Total		228	124	30	382	.000

See pages 47 - 108 for financial disclosure information.

Long-Acting Local Anesthetic in Ankle Fractures Requiring ORIF Reduces Postoperative Narcotic Use: A Randomized Trial

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Purpose: Our objective was to determine the efficacy of liposomal bupivacaine with bupivacaine compared to placebo for postoperative pain control in patients undergoing operative fixation of ankle fractures.

Methods: After IRB approval, 50 patients with acute ankle fractures (OTA 44A-C) requiring operative fixation that met inclusion criteria were identified at a Level I trauma center. Patients were randomly assigned to one of two groups, standard of care (general anesthesia alone) or local intraoperative liposomal bupivacaine with bupivacaine (interventional) and remained blinded to study arm. Postanesthesia care unit (PACU) pain medications administered and pain according to visual analog scale (VAS) were recorded. Patients were discharged on oxycodone/acetaminophen (Percocet) 5/325 mg for pain control. Pain levels and pain medications taken were recorded at postoperative time points of 4, 24, 48, and 72 hours by a trained researcher. Patients followed up in the operative surgeon's office until union and then continued to be followed until maximal medical improvement. At each follow-up visit, patients were given a short questionnaire regarding satisfaction with pain control. Pain scores were again recorded using VAS at these visits.

Results: 23 males and 27 females (mean age = 45 ± 16 years) were enrolled and obtained adequate follow-up. 26 patients were randomized to the control group and 24 to the interventional group, with no statistically significant differences between groups with regards to severity of injury and patient demographics including gender, age, and body mass index (BMI). Pain scores were lower in the interventional group versus control at each time point assessed, achieving significance for pain levels at 4 hours (3.4 vs 5.8, P = 0.01). Percocet ingestion at 4 hours and 48 hours postoperatively were significantly lower in the interventional group (0.35 vs 1.1, P = 0.004, and 1.5 vs 2.6, P = 0.007, respectively) with no significant differences in Percocet taken postoperatively at all other time points assessed (P = 0.243, P = 0.606). There was no significant difference regarding PACU morphine use between the control group and the interventional group (0.74 doses vs 0.45 doses, P = 0.301). There was no difference in pain score and total pain medication used between postoperative day three and postoperative day fourteen (P = 0.684, P = 0.378, respectively). The overall satisfaction with pain control was not statistically different between the two groups (P = 0.467).

Conclusion: Local intraoperative infiltration of liposomal bupivacaine with bupivacaine for ankle fractures requiring open reduction and internal fixation (ORIF) affords improved pain relief in the immediate postoperative period resulting in a reduction in Percocet ingestion, with resultant effects seen up to two days postoperatively. Interestingly, this reduction did not result in a reduced length of PACU stay, reflecting the comprehensive criterion composing PACU discharge. Continued investigation of this drug for use with extremity fractures is warranted.

Association Between Opioid Intake and Disability After Operative Treatment of Ankle Fractures

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Background/Purpose: The opioid-centric pain management strategies in the United States have contributed to an epidemic of prescription opioid abuse that is the most common cause of death of young adults. A prospective cohort study documented comparable pain intensity and satisfaction with pain relief after open reduction and internal fixation (ORIF) of an ankle fracture among patients using acetaminophen in the Netherlands and oxycodone in the United States. Another prospective cohort study found that increased inpatient opioid intake after operative fracture treatment was associated with more pain and decreased satisfaction with pain relief independent of the type, number, and severity of fractures. The effective coping strategy of self-efficacy was associated with less pain and greater satisfaction with pain relief after fracture surgery. In yet another prospective cohort study, opioid intake 1 to 2 months after fracture surgery correlated with psychological distress (PTSD [posttraumatic stress disorder], symptoms of depression). Studies consistently identify psychosocial factors as more strongly associated with symptom intensity and magnitude of disability after injury. Continuing this line of research, this prospective cohort study addressed the null hypothesis that disability (Foot and Ankle Disability Measure) at suture removal does not correlate with opioid intake, measured by oral morphine equivalents following ankle fracture surgery, accounting for demographics, trauma and surgery factors, treatment satisfaction, and psychological measures. Secondarily we assessed disability at 5 to 8 months after surgery and treatment satisfaction.

Methods: Following institutional review board approval, we prospectively enrolled 102 adult patients at suture removal after ankle fracture surgery, no more than 4 weeks after injury. We recorded patient demographics, opioid use before injury, oral morphine equivalents taken between discharge and suture removal, injury mechanism, Pain Anxiety Symptoms Scale, Pain Catastrophizing Scale, symptoms of depression (Patient Health Questionnaire-2), 11-point ordinal rating scales for active and resting pain intensity and for satisfaction with pain management and overall treatment, and foot and ankle-specific disability (Foot and Ankle Disability Measure). To address our secondary study questions 59 patients (60%) completed questionnaires 5 to 8 months after surgery.

Results: Accounting for interaction between variables using multivariable analysis there was no association of taking opioid medication and disability at the time of suture removal. Being married (β regression coefficient [β] 13, 95% confidence interval [CI] 4.2 to 21, $P = 0.003$; partial R2 0.087), sports injuries (β 15, 95% CI 4.7 to 26, $P = 0.005$; partial R2 0.080), and less pain catastrophizing (β -1.2, 95% CI -1.7 to -0.72, $P < 0.001$; partial R2 0.20) were associated with less disability at the time of suture removal. Among the 60% of patients evaluated 5 to 8 months after surgery, greater disability was independently associated with more pain anxiety (β -1.1, 95% CI -1.7 to -0.48, $P = 0.001$; partial R2 0.19). Greater treatment satisfaction at suture removal was independently associated with less pain catastrophizing (β-0.088, 95% CI -0.12 to -0.053, $P < 0.001$; partial R2 0.21). Five to eight months after surgery,

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no variables were associated with treatment satisfaction. Additionally, greater pain at rest at suture removal was associated with more oral morphine equivalents at suture removal (β 0.042, 95% CI 0.0021 to 0.063, P <0.001; partial R2 0.14) and greater pain with activity at suture removal was associated with more oral morphine equivalents at suture removal (β 0.048, 95% CI 0.024 to 0.072, P <0.001; partial R2 0.14).

Conclusion: Opioid use and injury characteristics were not independently associated with disability or treatment satisfaction in patients recovering from ankle fracture surgery. Managing psychological distress and optimizing coping strategies are consistently identified as the best opportunities for decreasing symptom intensity and magnitude of disability during recovery from musculoskeletal trauma. It's time to move away from the opioid-centric model for pain management and proactively address stress, distress, and ineffective coping strategies.

Incisura Morphology as a Risk Factor for Syndesmotic Malreduction

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Background/Purpose: Although it has been recognized that syndesmoses have variable morphology among the population, previous studies have not shown an association between incisura morphology and malreduction following injury. Recently, specific measurements have been developed to assess the syndesmotic reduction based on bilateral CT scans. The effect of syndesmotic morphology on reduction accuracy has not been established. We hypothesized that sagittal plane and rotational reduction would vary based on depth of the syndesmotic incisura.

Methods: At a single institution, a prospective cohort of 35 patients with injuries to the syndesmosis underwent postoperative CT scans of the bilateral ankles after open reduction and internal fixation (ORIF) of the malleoli and syndesmosis. The accuracy of the syndesmotic reduction was assessed by comparing the operative ankle to the contralateral, uninjured ankle. The depth of the incisura was quantified at a level 1 cm proximal to the tibial plafond. The patients were subdivided into shallow (<2.5 mm, 8 patients), average (2.5-4.5 mm, 18 patients), and deep (>4.5 mm, 9 patients) incisura.

Results: There was a significant correlation between more shallow syndesmoses and increased anterior translation of the fibula in the incisura ($r = -0.63$, $P < 0.001$). Six of the "shallow" patients (75%) were anteriorly malreduced 1.5 mm or greater compared to the contralateral ankle. The "shallow" anterior malreduction rate in those with a shallow incisura was significantly greater than in the "non-shallow" patients ($P < 0.001$). Five of the "deep" patients (55%) had posterior malreductions >1.5 mm. The posterior malreduction rate in the "deep" group was significantly greater than the "non-deep" patients ($P = 0.02$). There was a significant correlation between increasing syndesmotic depth and increased malrotation ($r = 0.34$, $P = 0.048$).

Conclusion: Syndesmotic morphology was found to be associated with specific malreduction patterns. Shallow syndesmoses were correlated with anterior fibular malreduction, and were less likely to be malrotated. Conversely, deep syndesmoses predispose to posterior sagittal plane and rotational malalignment. Preoperative CT scans that assess the syndesmosis morphology may allow surgeons to alter reduction strategies to avoid syndesmotic malreduction.

See pages 47 - 108 for financial disclosure information.

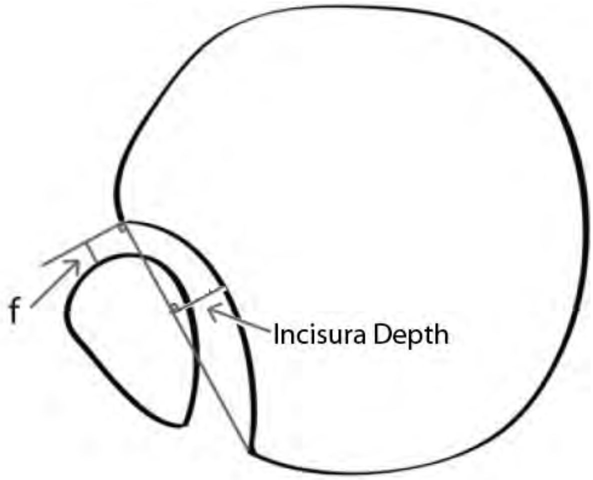

Figure 1- Demonstrates the measurements taken at 1cm proximal to the tibial plafond. The incisura depth was measured in addition to the anterior-posterior translation of the fibula (measurement f)

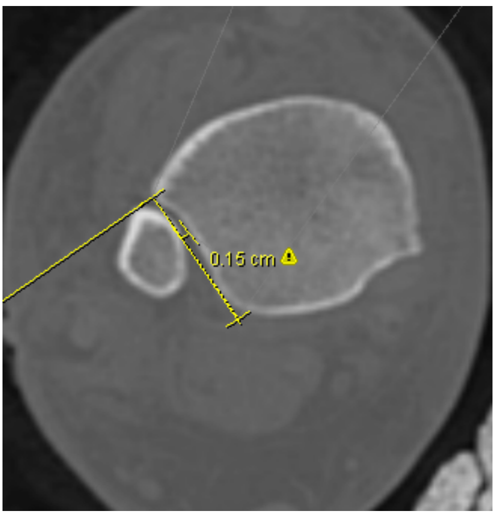

Figure 2- injured limb showing anterior translation of fibula in shallow native incisura on post-operative CT scan. Syndesmosis depth is shallow (0.15cm), and the fibula is at the level of the anterior point of the incisura (f= 0cm)

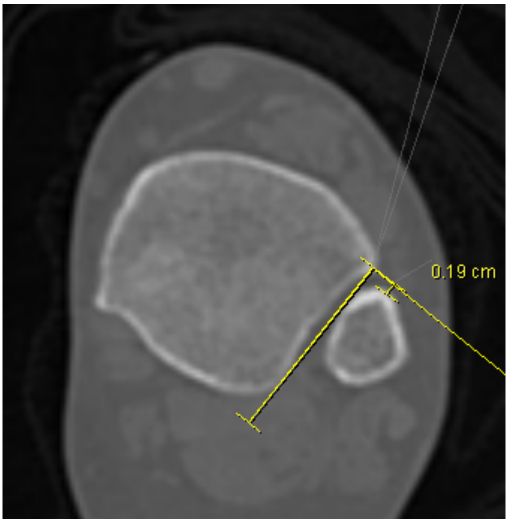

Figure 3-uninjured limb as control, measurement f=0.19cm.

Does Physical Therapy Predict Outcomes after Ankle Fractures and Ankle Fracture-Dislocations?

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Purpose: Despite the widespread use of physical therapy for treatment of lower extremity injury and specifically for ankle fractures, its role in functional rehabilitation and patient outcomes is poorly understood. Although addressed by several authors, no definitive study has determined the treatment effect of postoperative physical therapy for this group. The purpose of this study is to determine the pragmatic effectiveness and outcomes associated with physical therapist-supervised rehabilitation (PT) compared to surgeon-directed rehabilitation (NoPT). We hypothesized that the long-term clinical outcomes for patients who receive supervised physical therapy-directed rehabilitation will have similar outcome to those receiving surgeon-directed rehabilitation.

Methods: After IRB approval, 80 patients with bimalleolar or trimalleolar ankle fractures with or without dislocation were enrolled in a prospective observational study. The study population included patients with displaced ankle fractures or fracture dislocations who were treated operatively. Injury characteristics, patient demographics, and pre/post fixation and follow-up radiographs were captured. Patient-reported outcome scores were assessed using FAAM (Foot and Ankle Ability Measure) and SFMA (Short Musculoskeletal Function Assessment) questionaires at 6,12, and 24 months. Patients were prescribed physical therapy at the discretion of their treating surgeon based upon their clinical judgement and patients' individual postoperative course between 6 weeks - 6 months. Patient reported outcome scores and complication rates for patients receiving therapist-directed rehabilitation (PT) were compared to those receiving physician-directed rehabilitation (NoPT).

Results: Of the 80 patients, 38 patients (47.5%) were prescribed supervised rehabilitation (PT) while the remaining received exercise instruction from the physician or ACP at a clinic visit (NoPT). 34 patients (89.5%) attended at least one PT session. Number of sessions attended by each patient ranged from 1 to 36 (average = 16). Whether or not a patient received a PT prescription did not differ by injury characteristics or demographics but did differ by insurance status. 37 (56%) of patients with insurance versus 1 (7%) patient without were prescribed PT ($P < 0.001$). Patient-centered outcome scores collected at 6 months show mean FAAM score of 69.7 for PT compared to 70.9 for NoPT groups ($P = 0.868$). Combination SMFA scores for PT cohort were 20.1 compared to 24.4 in NoPT group ($P = 0.454$), and there were no significant differences on any of the subscale scores. Physician and practice-specific differences were observed between provider subset groups. Postoperative complications were rare and equivalent between the groups. Costs associated with the PT group were $125.81 average per patient/session. The total cost of supervised rehabilitation was $62,401 for our patient cohort.

Conclusion: The comparison of the outcomes between patients with operatively treated displaced ankle fractures or ankle fracture-dislocations with therapist-directed versus

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physician-directed rehabilitation showed no difference in validated SMFA and FAAM outcome scores. These findings would suggest that patients receiving supervised physical therapy produced a similar outcome to those under routine physician-directed rehabilitation at 6 months postoperatively. The cost related to the therapy averaged $2012.96 per patient receiving PT.

See pages 47 - 108 for financial disclosure information.

Peroneal Irritation After Lateral Malleolar Fractures

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Purpose: Peroneal irritation is a common finding after open reduction and internal fixation (ORIF) of lateral malleolar fractures. It has been correlated with posterior plate position, but no specific investigation has been performed to determine factors associated with this finding. There were two goals of this trial: first, to evaluate the patient, surgical, and construct factors associated with peroneal symptoms; second, to document the incidence of peroneal symptoms over time after fixation.

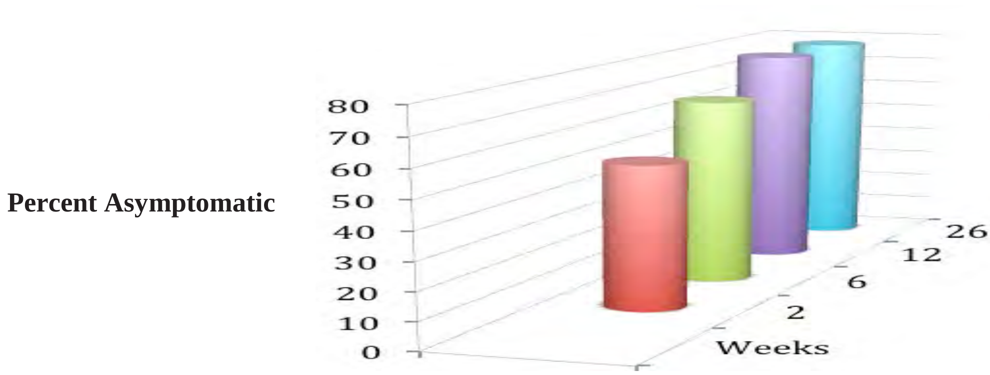
Methods: 227 patients with Weber B ankle fractures were prospectively evaluated at 2, 6, 12, and 26 weeks after fibular fixation in a multicenter trial. Patient demographics, plate location and position, and syndesmotic fixation were documented. At each follow-up examination, the status of the peroneal tendons was documented as: asymptomatic, sensitive to touch, occasionally bothersome, or significantly bothersome. Comparisons were made between asymptomatic versus all other groups and between asymptomatic or sensitive to touch versus any category or bothersome. Statistical significance was set at $P < 0.05$.

Results: 227 patients were enrolled and form the basis of this trial. There were 128 women and 99 men aged 18-77 years (average 43) treated with 114 lateral and 113 posterior plates. At 6 months of follow-up none of age, gender, race, ISS, BMI (body mass index), incision length, posterior versus lateral plating, plate length, number of screws distal to the fracture, or the presence of syndesmotic fixation correlated with peroneal symptoms when comparing asymptomatic against all others, or when comparing any level of bothersome versus not. However, active smokers were less likely to be asymptomatic ($P = 0.0004$) and more likely to have bothersome sequelae ($P = 0.006$). Patients with low-energy injuries were more likely to be asymptomatic ($P = 0.0001$). There was a greater distance from the tip of the fibula to the plate in asymptomatic patients compared to all others ($P = 0.05$). The percentage of asymptomatic patients improved from 52% at 2 weeks, to 67% at 6 weeks, and stabilized at 78% by 12 weeks (figure).

Conclusion: The rate of peroneal symptoms after ankle fracture stabilizes by 12 weeks. Smokers and patients who sustained high-energy injuries had greater rates of peroneal symptoms.

The only surgeon-controlled factor predicting peroneal symptoms was a shorter distance from the tip of the fibula to the plate. Surgeons should attempt to keep plates as proximal as feasible. Additionally, smoking cessation should be examined as a possible intervention.

Peroneal Irritation After Lateral Malleolar Fractures



See pages 47 - 108 for financial disclosure information.

Reduction Clamp Force Associated with Syndesmotic Overcompression: A Pilot Study

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Background/Purpose: Syndesmotic malreduction is one of the strongest predictors for a poor outcome in patients with ankle trauma. Recent studies have found that syndesmotic overcompression is possible and very common. Syndesmotic reduction typically involves using a reduction clamp to position the fibula within the distal tibial incisura. The relationship between the magnitude of force generated by the reduction clamp during syndesmotic reduction and the incidence of syndesmotic overcompression has not been previously studied. The purpose of this study was to quantify the clamp force used during syndesmotic reduction and to evaluate the effect of clamp force on overcompression in a clinical cohort. Our hypothesis was that increased reduction clamp force will lead to syndesmotic overcompression.

Methods: A prospective cohort of 21 patients with syndesmotic injuries treated with clamp reduction and screw fixation were enrolled. A standard pointed reduction clamp modified to include a load cell on one tine was utilized for syndesmotic reduction. One of three fellowship-trained orthopaedic trauma surgeons reduced the syndesmosis using standard techniques using the modified load cell clamp. Clamp force was recorded after final clamping and prior to screw fixation. Reduction was assessed fluoroscopically, and compared to the contralateral uninjured ankle. Surgeons were blinded to the clamp force. Bilateral ankle CT scans were obtained postoperatively to assess reduction accuracy. Multiple standardized measurements, based on a previously published protocol, were used to assess reduction. These measurements evaluated sagittal and coronal plane translation, and rotation of the fibula relative to the incisura. "Overcompression" was defined as 1 mm or greater of difference in fibular medialization when comparing the operative side to the noninjured side. The clamp force was also correlated to patient factors including BMI (body mass index), age, and number of days from injury to surgery. Two-tailed t tests and Pearson correlations were used to compare the results of the reduction with the intraoperative clamp force, as well as correlate clamp force with the patient factors, using $P < 0.05$ as significant.

Results: Increased clamp force significantly correlated with syndesmotic overcompression ($r = 0.444$, $P = 0.044$). Syndesmotic overcompression was seen in 11 of 21 patients (52%). Two patients (10%) had undercompression of the syndesmosis of >1.0 mm compared to the noninjured side. Eight patients (38%) had adequate syndesmotic compression, where the coronal plane fibular translation was within 1.0 mm of the noninjured side. The mean reduction clamp forces were 88 N (standard deviation [SD] 11) for the undercompressed group, 130 N (SD 56) for the adequately compressed group, and 163 N (SD 79) for the overcompressed group. The overall range of recorded clamp force was 36 to 261 N. Of the patient factors examined, both increased BMI ($r = 0.140$) and days from injury to surgical fixation ($r = 0.101$) positively correlated with increased clamp reduction force.

Conclusion: This pilot study demonstrated a significant correlation between increased clamp forces and syndesmotic overcompression, and determined objective forces that lead

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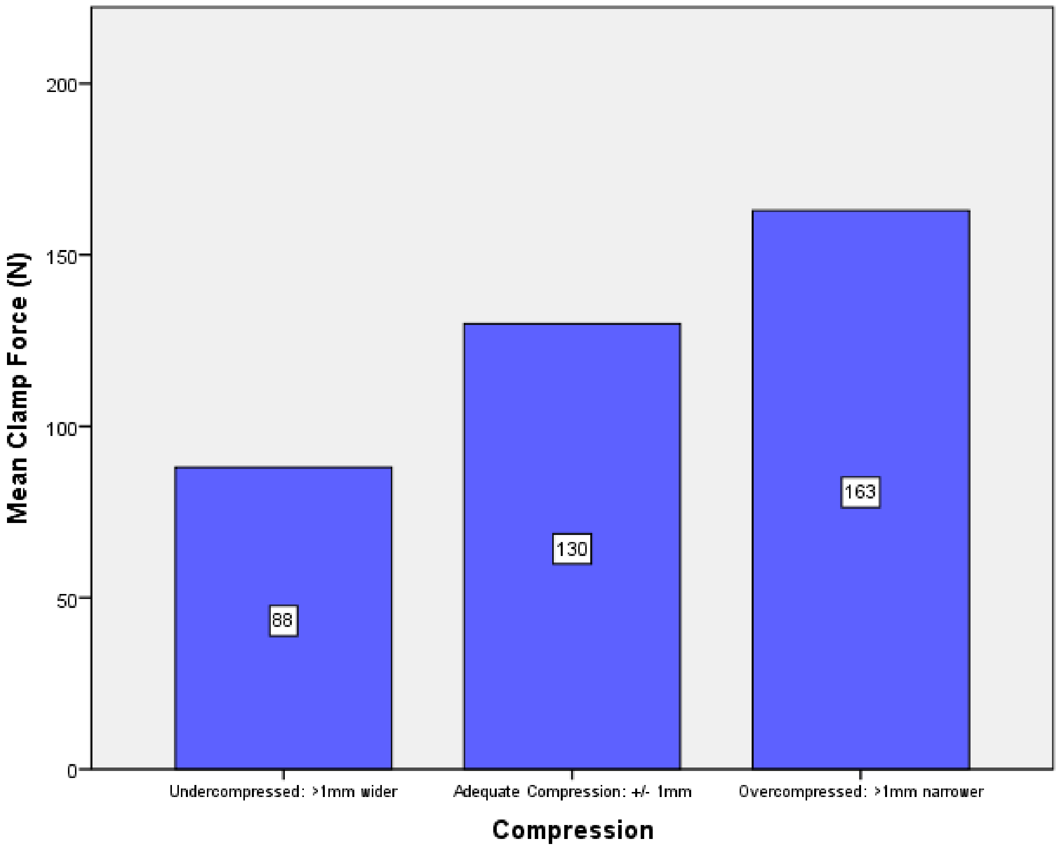
The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or medical device he or she wishes to use in clinical practice.

to overcompression. Biomechanical studies have shown that the distal tibiofibular joint undergoes physiologic widening with ankle dorsiflexion, therefore it is likely that over-compression and rigid fixation of the syndesmosis results in decreased ankle motion. Our results indicate that surgeons should be cognizant of the clamp force used for syndesmotic reduction. Further investigation will correlate clamp force and overcompression to ankle range of motion and functional outcomes.

Figure 1. Reduction Clamp Force vs. Amount of Syndesmotic Compression



See pages 47 - 108 for financial disclosure information.

A Clinical Comparison of Treatment of Deltoid Ligament Injuries in Ankle Fracture: Repairing the Deep Deltoid or Superficial or Not

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Background/Purpose: Decades ago, it was common for surgeons to repair the injured deltoid ligaments at the time of fibular osteosynthesis. In the last 30 years, many reports showed no significant difference in outcomes when patients received conservative or surgical treatment if the medial clear space reduced in Weber type B and C fractures. However, there has been varied opinion on when to do open repair of the deltoid ligament. This study compared the clinical outcomes in patients with repairing the injured superficial deltoid ligaments and deep deltoid ligaments, and patients without direct surgical intervention after anatomic restoration of the fibular fracture and the medial clear space.

Methods: Since April 2013, a prospective study of ankle fractures associated with deltoid ligament rupture and lateral or lateral-posterior dislocation of the talus was conducted on 3 groups of subjects: 22 patients were treated by superficial deltoid ligament repair, 25 patients received deep components augmentation at the time of fibular osteosynthesis, and 21 patients accepted no direct surgical intervention. For the deep components group, a suture anchor was placed in the talus at the talar insertion of the deep deltoid ligaments and the four suture limbs were passed through the bony canal of medial malleolus to augment them. For the superficial one, the suture anchor was placed in the tip of medial malleolus, and sutured the injured ligaments directly. All the patients were evaluated with stress views preoperatively and intraoperatively. The outcomes were evaluated with Philips and Schwartz clinical scoring system of ankle and AOFAS (American Orthopaedic Foot & Ankle Society) Ankle-Hindfoot Scale.

Results: 68 patients were followed for an average of 15 months. In the superficial components group, the mean degree of plantar flexion was 48.5°, with 2.3° (range, 0-10°) less than the normal side, the mean degree of dorsiflexion was 14.1°, with 6.8° (range, 0-15°) less than the normal side. In the deep components group, the plantar flexion was 49.1°, the dorsiflexion was 14.0°, with 2.6° (range, 0-10°) and 6.9° (range, 0-14°) less than the normal side. In the nonrepaired group, the plantar flexion was 49.4°, the dorsiflexion was 14.4°, with 2.2° (range, 0-10°) and 6.4° (range, 0-20°) less than the normal side. The mean Philips and Schwartz score was 92.8 (range, 80-100) in superficial group, 93.7 (range, 70-100) in deep group, and 93.8 (range, 85-100) in the nonrepaired group, while the AOFAS score was 94.3 , 94.6, and 93.7, respectively. According to the intraoperative stress views, we found that the repair group, especially the deep components repair group, can reduce the talus tilt and rotation under valgus and lateral rotational stress. However, no statistically significant intergroup differences were evident in terms of clinical outcomes.

Conclusion: This study did not support regularly exposing and repairing the injured deltoid ligaments whether superficial or deep components, since both repairing and nonrepairing achieved similar results. Repairing injured deltoid ligaments may be helpful to early talus

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stability postoperatively. For some cases in the deep components group, the augmentation of suture anchor replaced the syndesmosis screw and posterior malleolus fixation and improved the short-term outcome.

	Superficial group	Deep group	Non-repearing group
Mean degree of plantar flexion(FP)	48.5°	49.1°	49.4°
Difference from nomal of PF	2.3° (0-10°)	2.6° (0-10°)	2.2° (0-10°)
Mean degree of dorsiflexion(DF)	14.1°	13.8°	14.4°
Difference from nomal of DF	6.8° (0-15°)	7.2° (0-14°)	6.4° (0-20°)
Philips and Schwartz score	92.8 (80-100)	93.2 (88-100)	93.8 (85-100)
AOFAS Ankle-Hindfoot Scale	94.3 (82-100)	94.1 (85-100)	93.7(85-100)

See pages 47 - 108 for financial disclosure information.

The Diagnostic Accuracy of Mortise Radiographs and MRI in Predicting Deltoid Ligament Ruptures in Supination External Rotation Ankle Fractures

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Purpose: Supination external rotation (SER) ankle fractures represent the most common pattern of ankle injury, and operative indications for these injuries depend on the integrity of the medial structures. In the absence of a medial malleolus fracture, the status of the deep deltoid ligament should determine whether operative or conservative treatment is indicated. Despite the importance of assessing deep deltoid ligament injuries in these patients, the accuracy of common diagnostic tests has not been established. The objective of this study was to compare the ability of injury and stress radiographs and MRI to diagnose deep deltoid ligament ruptures in operative SER ankle fractures.

Methods: Patients who underwent open reduction and internal fixation of SER ankle fractures from 2010 to 2013 by a senior surgeon were identified from a prospective registry. Patients with medial malleolus fractures were excluded. Inclusion criteria consisted of all patients with an injury mortise ankle radiograph, manual stress test radiographs if the medial clear space (MCS) <5 mm on injury radiographs, preoperative ankle MRI, and intraoperative assessment of deep deltoid integrity by direct visualization. The MCS was considered positive for all values >5 mm on the injury or stress mortise radiographs. MRI analysis of the deep deltoid ligament injury was performed by two fellowship-trained musculoskeletal radiologists. Intraoperative direct visualization of the deltoid was performed using a medial ankle approach by a single surgeon who recorded the integrity of the deep deltoid.

Results: 53 patients met the inclusion and exclusion criteria. Based on intraoperative direct visualization, 46 patients (87%) had a complete rupture of the deep deltoid. Using intraoperative visualization as the gold standard, MCS measurements diagnosed a deep deltoid ligament rupture with 91% sensitivity, 14% specificity, and accuracy of 81%. MRI had a sensitivity of 80%, specificity of 100%, and accuracy of 83% to diagnose a deep deltoid rupture. In cases where the MCS was <5 mm on injury radiographs and stress tests were performed, MCS measurements were much less accurate than MRI in predicting deltoid ruptures (53% vs 80%, respectively). In contrast, an MCS measurement of greater than 5 mm on injury radiographs was a strong predictor of deltoid rupture (accuracy of 92%).

Conclusion: Diagnosing deep deltoid ligament injuries in SER ankle fractures often dictates treatment options; however, the ability of common diagnostic tests to predict these injuries is unknown. Using direct visualization of the deltoid ligament intraoperatively as the gold standard, these data support the diagnosis of deltoid ruptures when the MCS measurement is >5 mm on injury radiographs. However, when the MCS is <5 mm on injury radiographs, MRI has improved accuracy over stress tests. Given these data, we recommend proceeding with surgery when the MCS on injury radiographs is >5 mm without any additional stress tests or advanced imaging. When the MCS is <5 mm, we recommend MRI analysis because of its increased accuracy and decreased false negatives compared to stress test. Understanding and improving our ability to diagnose deltoid ligament ruptures will contribute to effective treatment algorithms for patients with SER ankle fractures.

Medial Clamp Tine Positioning Using Intraoperative Fluoroscopy Affects Syndesmosis Malreduction

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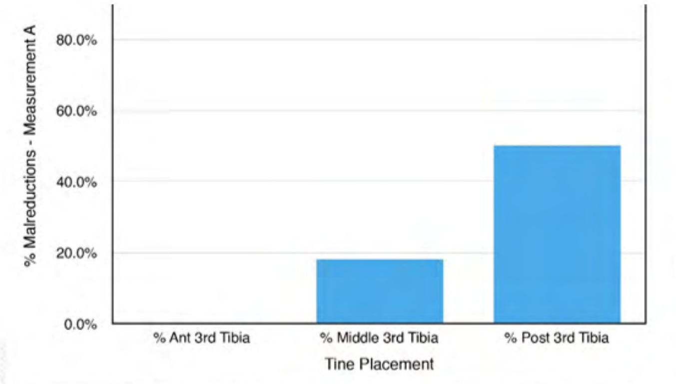
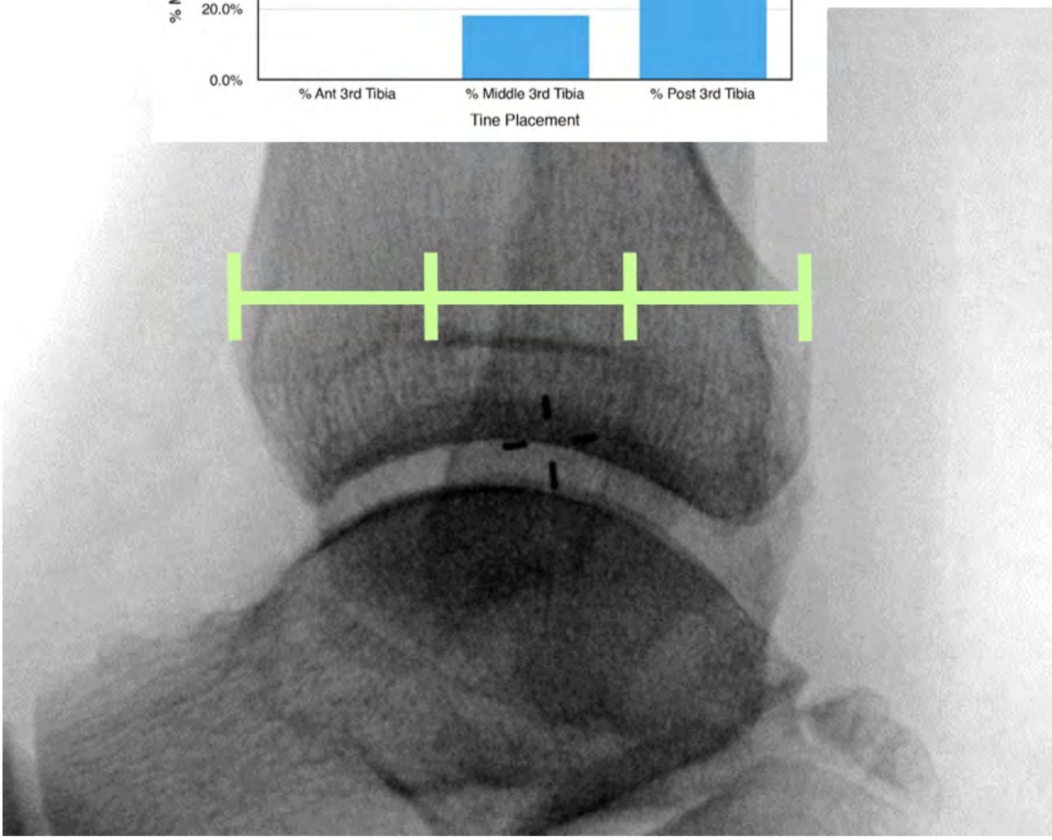
Background/Purpose: Treatment of ankle syndesmotic injuries requires precise anatomic reduction to provide optimal functional outcomes. Several recent studies have demonstrated unacceptably high malreduction rates. The ideal technique for reduction and intraoperative reduction assessment has been contested in the literature. The purpose of this study was to determine if the position of the medial clamp tine during syndesmotic reduction affected malreduction rates.

Methods: We prospectively enrolled 36 patients with malleolar ankle fractures and concomitant syndesmotic injuries into a study to assess multiple aspects of syndesmotic reduction and fixation. Patients had their malleoli fractures stabilized, and underwent stress examination of the syndesmosis. If the syndesmosis was unstable compared to the contralateral side, reduction and fixation was performed. Reduction was achieved using a reduction forceps, without visualization of the distal tibiofibular joint, by one of three orthopaedic traumatologists at a Level I center. The lateral clamp tine was placed on the fibular tubercle, or on a screw head on a posterolateral plate. The medial clamp tine was placed anteromedially on the distal tibia based on each surgeon's standard technique. Bilateral CT scans were obtained postoperatively. Various standardized measurements of syndesmotic reduction were performed based on several previous parameters described in the literature. Malreduction was defined as a difference of 2 mm between the injured and uninjured sides. Next, the true talar dome lateral flurosocopy view was evaluated and measured to determine the medial clamp tine positioning on the true talar dome lateral relative to AP dimension of the tibia. A Fisher exact test was performed to assess for statistical association between medial clamp tine placement on intraoperative fluoroscopy and malreduction.

Results: A significant association was found between medial clamp position and sagittal plane translational malreduction of the syndesmosis. In 10 patients, the tine was placed in the anterior third of the tibial line, and there were no malreductions; in 22 patients, the medial clamp tine position was located in the central third of the tibia, and 4 (18%) malreductions occurred. Of the 4 patients in whom the clamp tine was in the posterior third, 2 (50%) malreductions occurred (P = 0.05, Figure). There were no significant associations between medial clamp placement and coronal plane (overcompression) or rotational malreductions.

Conclusion: When using reduction forceps for syndesmotic reduction, the position of the fibular clamp tine is relatively constant, but the position of the medial clamp tine can be highly variable. The eccentric angle created with off-axis syndesmotic clamping is likely a major culprit in iatrogenic malreduction. A true talar dome lateral image during intraoperative fluoroscopy creates a reproducible template on which deliberate medial clamp tine positioning can be performed. Sagittal plane malreduction appears to be highly sensitive to clamp obliquity, which is directly related to the medial clamp tine placement.





See pages 47 - 108 for financial disclosure information.

The Failed Pilon: Factors Associated with Delayed Amputation, Arthroplasty, or Arthrodesis after Open Reduction and Internal Fixation

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Purpose: Pilon fractures are devastating injuries, with high reported rates of postoperative complications and persistent functional morbidity after open reduction and internal fixation (ORIF). The purpose of this study was to compare factors associated with tibial pilon fractures that failed ORIF, later requiring delayed amputation, arthroplasty, or arthrodesis.

Methods: Study design was a case control with 1:1 matching for controls, by date of surgery. Inclusion criteria included: age >18 years, OTA type 43B or 43C tibial plafond fractures treated with ORIF at a single institution. For the cases, "failure" was defined as amputation, arthrodesis, or arthroplasty performed at greater than 3 months post-ORIF. For controls, a minimum of 3 months of follow-up was needed. Demographic variables were collected, which included: age, gender, race, body mass index (BMI), marital status, diabetes, vascular disease, smoking, alcohol, Workers' Compensation. Injury variables were collected, which included: open versus closed injury, OTA type, vascular injury, radiographic severity score, radiographic alignment, bone loss, impaction, anterior plafond impaction, fibula fracture location. Operative variables were collected, which included: single versus two-stage treatment of the pilon component, and need for flap coverage. Complications of minor (requiring oral antibiotics) or major (requiring operative debridement or intravenous antibiotics) infection were recorded. Univariate analysis was performed for each variable, with odds ratios reported, and significance at P <0.05. Results were entered into stepwise logistic regression for variables with P <0.1.

Results: Between January 2000 and May 2014, 1560 43B or 43C injuries were treated with ORIF. 37 met the inclusion criteria for failure (21 fusion, 9 amputation, 7 arthroplasty) and 37 controls were matched. The average length to follow-up was 764 days (cases) and 452 days (controls). Factors associated with failure were: OTA type (C-type odds ratio [OR] 5.6, P <0.01), two-stage management (OR 5.44, P= 0.02), minor infection (OR 7.9, P = 0.01), major infection (OR 12.6, P <0.01), radiographic overall severity (P <0.001), radiographic articular severity (P <0.001), plafond impaction (OR 8.14, P <0.001), and anterior plafond impaction (P <0.001). Stepwise logistic regression demonstrated major infection (P = 0.03), overall radiographic severity (P = 0.01), and anterior impaction (P = 0.006) to be most predictive of pilon failure.

Conclusion: Multiple injury factors, including anterior impaction, overall radiographic severity, and major infection, were associated with failure of ORIF of tibial pilon fractures, which required delayed amputation, arthrodesis, or arthroplasty. Early recognition of the injury factors and early intervention, perhaps at the time of injury with a salvage procedure, may improve the reportedly high rates of poor outcomes following these injuries. In addition, patients with infections should be counseled about the severity of their injury.

Fixation of Tibial Pilon Fractures: Which Side of the Tibia Do I Plate?

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Purpose: Understanding fibular fracture morphology is crucial for the treatment of pilon fractures. Comminuted fibular fractures (compression failure) occur with the tibial component following a valgus force. Transverse fibular fractures (tension failure) occur with varus stress to the tibial component. No definitive guideline for determining the location of tibial fixation currently exists. We hypothesize that plate fixation on the anterolateral tibia for valgus fibular failures and medial tibial plating for varus fibular fractures will be superior and demonstrate fewer complications.

Methods: Pilon fractures were identified from our database and reviewed with the inclusion criteria for this retrospective study. Pilon fractures were classified with AO/OTA and included 43-A through 43-C fractures. Inclusion criteria included skeletal maturity, presence of an associated fibular fracture, and definitive tibial plating. Primary factors assessed included age, sex, weight, mechanism of injury, fibular fracture type (comminuted or transverse), tibial plate location (medial or lateral), location of open wound (if any), time to definitive fixation, time to full weight bearing, and complications. Patients were grouped based on the fibular component fracture type (comminuted vs transverse), and the location of plate fixation (medial vs lateral) was noted. Clinical outcomes were compared using a chi-square test for nominal data and t test for continuous variables.

Results: 407 patients were identified. 120 fractures in 119 patients (61 men and 58 women) met inclusion criteria with appropriate follow-up. 48 fractures resulted from a varus force (transverse fracture of the fibula) and 72 were due to valgus forces (comminuted fibula). In the transverse fibular fracture group (n = 48), 14.3% that were correctly plated medially developed mechanical complications. 83.3% that were incorrectly plated laterally developed mechanical complications ($P \leq 0.001$). For comminuted fibular fracture type (valgus), 35.1% of incorrectly medially plated fractures demonstrated mechanical complications versus 17.1% for fractures correctly stabilized with a lateral plate ($P = 0.083$). Time to weight bearing as tolerated (WBAT) was significant between groups plated medially and laterally for varus (transverse) fibula fractures ($P \leq 0.001$) and (valgus) comminuted fibular fractures ($P = 0.01$) in favor of the appropriately applied plate. Overall rate of nonunion/malunion was 25%, with the majority related to mechanical failures due to incorrect plate location.

Conclusion: Correctly assessing the fibular component for pilon fractures provides valuable information regarding deforming forces. Using this as a guide for correct tibial component plate location can minimize mechanical failures and malunion/nonunion. Soft-tissue injury remains an important factor in determining surgical approach; however, plates should be applied such that the tension band is re-established and can resist the original deforming forces as described by the fibular fracture morphology.

See pages 47 - 108 for financial disclosure information.

Predictors of Amputation in High-Energy Forefoot and Midfoot Injuries

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Purpose: High-energy forefoot and midfoot injuries are known to be high morbidity events but are poorly described in the literature. Patients with these injuries are challenging clinically as many will ultimately require a decision of limb salvage or amputation. The purpose of this study was to identify risk factors predictive of amputation in high-energy forefoot and midfoot injuries.

Methods: All patients presenting to our Level I trauma facility between January 2005 and December 2014 with a minimum of two foot fractures were reviewed, yielding 1970 unique patients. This cohort was then filtered for patients who sustained multiple fractures of the midfoot and forefoot with high-energy mechanisms, yielding 144 patients with 151 qualifying injured feet. Patient characteristics (age, comorbidities, tobacco use, body mass index [BMI]), fracture and dislocation patterns, and soft-tissue injury severity (open vs closed, Gustilo classification, location of wound, vascular injury, sensory loss) data were collected. Patients were grouped by mechanism into one of 5 categories: (1) falls from height, (2) restrained motorized collisions, (3) unrestrained motorized collisions, (4) direct-contact blunt trauma, and (5) industrial injuries. Operative reports were reviewed for the timing and levels of amputation (transmetatarsal through below-knee amputation [BKA]) at any time in their postoperative course. Cumulative incidence rate of amputation versus days since injury was estimated using a Kaplan-Meier survival analysis. Association between each variable and amputation was evaluated using a univariate Cox proportional hazard model. Statistical significance was set at a P value of <0.05.

Results: The 30-day amputation rate in this cohort was 14.2% (95% confidence interval [CI]: 8.4-19.7) and rose to 20.9% (95% CI: 13.1-28.1) at 1 year post injury (Fig. 1) after which the rate stabilized at that level. Of the 27 amputations, 23 (85.2%) ultimately proceeded to BKA. Variables predictive of amputation were the total number of fractures (P = 0.01), open injury (P <0.001) to either the plantar (P <0.001) or dorsal (P <0.001) surface of the foot, Gustilo grade (P <0.001), vascular injury (P <0.001), loss of sensation to any surface of the foot (P <0.001), and injury mechanism (P = 0.04). Specific fracture patterns that were predictive of amputation were fracture of all 5 metatarsals (P <0.001) and independently, fracture of the first metatarsal (P = 0.002). Variables of interest that were not statistically significant predictors of amputation included the presence of associated fractures of the distal tibia and plafond (P = 0.35), the presence of midfoot dislocations (P = 045), tobacco use (P = 0.19), and all patient comorbidities. Hazard ratios (HR; 95% CI) showed that open fractures were 17.3 (5.96–50.05) times more likely to progress to amputation. Each additional fracture of the foot increased the probability of amputation by 25% (1.05–1.49). Fracture of the first metatarsal specifically increased the probability of amputation by a factor of 3.4 (1.57-7.17) while fractures of all five metatarsals increased the probability of amputation by a factor of 9.8 (4.18-22.77). Patients who sustained direct blunt trauma (HR 11.39; 95% CI

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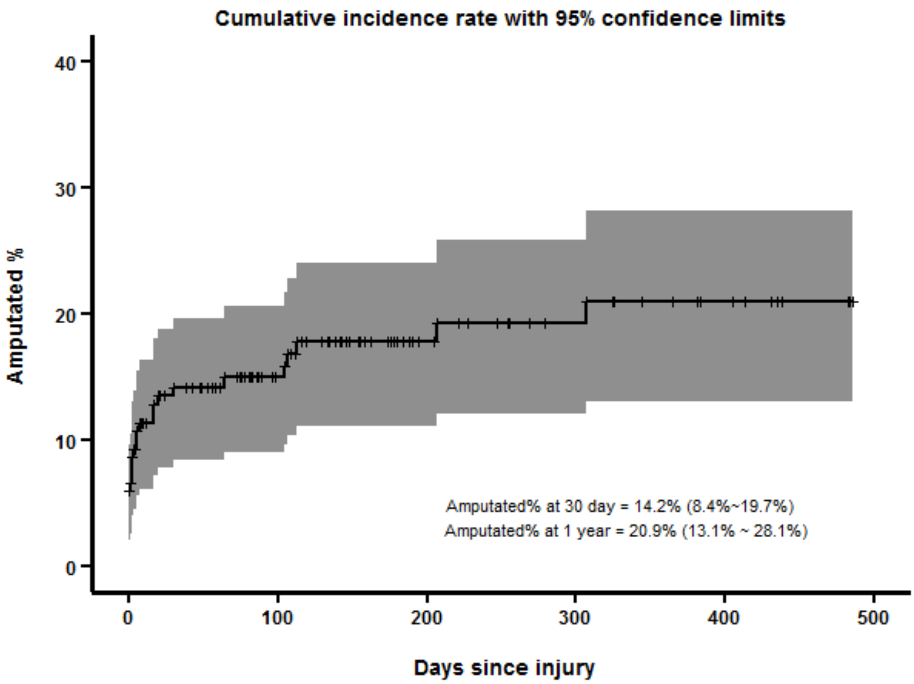
1.49-87.17) and industrial (HR 11.73; 95% CI 1.22-112.83) mechanisms of injury were most likely to receive an amputation.

Conclusion: High-energy forefoot and midfoot injuries are associated with a high degree of morbidity; 20% of patients sustaining these injuries proceeded to amputation within 1 year. Using the findings of this hazard model, providers will be able to utilize the presenting characteristics of the injury to counsel patients regarding the severity of their injury and the possible need for subsequent amputation.



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See pages 47 - 108 for financial disclosure information.

A Randomized, Prospective Comparison of Bioabsorbable and Steel Screw Fixation of Lisfranc Injuries

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Purpose: The purpose of this study is to prospectively evaluate and compare the long-term clinical and radiographic outcomes of bioabsorbable (Smart Screw, Linvatec) and traditional steel screw fixation of the Lisfranc ligament complex in unstable Lisfranc injuries in a single surgeon's practice.

Methods: Between September 2008 and December 2013, 40 patients presented with acute, closed, unstable Lisfranc injuries. Patients that required a midfoot arthrodesis, such as those with chronic injuries or severe joint comminution, were excluded. On the day of surgery, 20 patients were randomized to receive 4.5-mm bioabsorbable screws while the remaining 20 were randomized to receive 4.0-mm steel screw fixation. All 20 patients that received steel screw fixation received additional surgery to remove this hardware by 9 months from their original surgery. Preoperative and postoperative function and pain was graded using the Foot and Ankle Ability Measure (FAAM) scoring system and a visual analog scale (VAS) of pain respectively. Radiographs were assessed for joint congruency, stability, and degenerative changes. Data regarding postoperative complications and revision surgeries were also recorded.

Results: All 40 patients (100%) with acute, closed, unstable, ligamentous Lisfranc injuries that randomly received either steel or bioabsorbable screw fixation returned for the final evaluation. All twenty patients who received bioabsorbable screws for Lisfranc fixation were evaluated with a mean follow-up time of 36.3 months. The mean FAAM score increased from 32.5 of 100 preoperatively to 91.2 of 100 at the time of final follow-up. The mean VAS pain score decreased from 4.7 of 10 preoperatively to 1.3 of 10 at final follow-up. One patient (5%) who received a single absorbable screw for Lisfranc fixation developed an inflammatory reaction at the head of the screw at 2 years after her original surgery. This portion of the screw had not completely absorbed by that time and was treated with removal of the screw head remnant. At the time of final follow-up, no patients that received absorbable screws developed posttraumatic instability but 2 of these 20 (10%) patients have developed posttraumatic midfoot arthritis. All twenty patients who received steel screws were evaluated with a mean follow-up time of 40.5 months. The mean FAAM score increased from 24.9 of 100 preoperatively to 89.6 of 100 at the time of final follow-up. This postoperative score is lower than that of the absorbable screw group, but not to a statistically significant degree ($P = 0.4$). The mean VAS pain score decreased from 6.5 of 10 preoperatively to 1.9 of 10 at final follow-up. This postoperative score is higher than that of the steel screw group, but not to a statistically significant degree ($P = 0.25$). Aside from hardware removal that was performed in all of these 20 patients by 9 months from their original surgery, none of these patients required subsequent procedures on their injured foot. None of these patients developed midfoot instability after hardware removal. At the time of final follow-up, 4 of these 20 (20%) patients have developed posttraumatic midfoot arthritis.

Conclusion: A comparison of outcomes from treating unstable ligamentous Lisfranc injuries with bioabsorbable and steel screws has not been previously reported in the orthopaedic literature. This study demonstrates that using either bioabsorbable or steel screws to treat these conditions results in a high rate of regaining normal midfoot function and stability. This study shows that using absorbable screws provides results that are equivocal to, if not better than, the traditional use of steel screws for treating unstable ligamentous Lisfranc injuries. In addition, the use of absorbable screws eliminates the need for an additional surgery to remove hardware. Studies with a larger patient population may be needed to further confirm these reported advantages when using absorbable screws to manage these injuries.

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Femoral Neck Shortening Is Associated with Worse Functional Outcome: Analysis of the Prospective Multicenter Study of Hip Fracture Outcomes in China (SHOC)

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Purpose: Young femoral neck fracture patients (age ≤55 years) require surgical fixation to preserve the native hip joint and accommodate increased functional demands. Recent reports have identified a high incidence of fracture shortening and this may have negative functional consequences. We sought to determine if fracture shortening is associated with poor functional outcome in young femoral neck fracture patients.

Methods: 142 femoral neck fracture patients ages 18-55 years were enrolled in a prospective cohort study in three Chinese hospitals. Patient, injury, and treatment variables were recorded at injury, 6 weeks, and 3, 6, 12, and 24 months. Patient-reported functional outcomes were measured with the Harris Hip Score (HHS), Timed Up and Go test (TUG), and Short Form (SF)-36 Physical Component Summary (PCS) at 1 year. Radiographic fracture shortening was measured along the long axis of the femoral neck and corrected for magnification. Severe shortening was defined as ≥10 mm. The primary analysis measured associations between severe radiographic shortening and functional outcomes at 1 year post-fixation. Continuous variables were summarized with their mean ± standard deviation. Statistical significance was set at P ≤0.05.

Results: 107 patients had complete radiographic and functional outcomes available for analysis at 1 year. The mean age of participants was 44.0 ± 10.7 years and 54% were male. 53% of fractures were displaced and 38% were vertically orientated (Pauwels Type 3). The mean functional outcome scores were: HHS 90 ± 11, TUG 12 ± 5 seconds, and PCS 49 ± 8. Major shortening occurred in 13% of patients and was associated with worse functional outcome scores: HHS mean difference 10 (P = 0.02), TUG mean difference 3 seconds (P = 0.08), and PCS mean difference 5 (P = 0.05).

Conclusion: Severe shortening is a clinically significant complication following fixation of young femoral neck fractures, occurring in 13% of patients in this population. The principle of fracture site compression utilized by modern constructs may promote healing; however, excessive shortening is associated with worse patient-reported outcomes and objective functional measures.

A Case-Control Study of Total Hip Arthroplasty After Failed Proximal Femoral Fracture Fixation

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Background/Purpose: Fractures of the proximal femur are becoming more prevalent as the population ages. Femoral neck and intertrochanteric fractures account for most proximal femoral fractures and although the initial treatment of these two injuries may differ, the salvage procedure for failed internal fixation is often a conversion to total hip arthroplasty (THA). The use of THA for failed internal fixation of hip fractures can restore function and reduce the need for subsequent reoperations; however, the distorted bony anatomy, scar tissue, and potential hardware around the hip result in a more challenging procedure in this subset of patients. The aim of this study was to investigate the clinical and radiographic outcomes in patients who have undergone THA after a failed fixation of a proximal femoral fracture.

Methods: This retrospective case-control study compared findings of patients who underwent THA after failed open reduction and internal fixation (ORIF) of a proximal femoral fracture to a primary THA for nontraumatic osteoarthritis. From 2004 to 2014, 40 patients received a THA after failed internal fixation of a previous proximal femur fracture. The matched cohort of patients was matched for date of operation, age, gender, and type of implant to control for their confounding effects on outcomes. The outcome measurements included length of surgery, drop in hemoglobin, length of hospital stay, blood transfusion rates, medical complications, dislocations, revision procedures, and clinical outcome scores at latest follow-up. Statistical analysis was performed using the Student t test and vhi-squared test with significance set at a P value <0.05.

Results: The cohort of patients with a salvage THA included 18 male and 22 female patients with a mean age of 73 years (range, 28-96 years) and mean follow-up of 3.1 years (range, 1-8.3). Those with failed internal fixation included 12 intertrochanteric fractures (10 DHS [dynamic hip screw], 1 IM [intramedullary] nail, 1 blade plate) and 28 femoral neck fractures (21 cannulated screws, 6 DHS, 1 blade plate). The mean time between the internal fixation of the fracture and the THA was 2.1 years (standard deviation [SD], 2.7 years) for intertrochanteric fractures and 8.5 years (SD, 13.8 years) for femoral neck fractures (P = 0.03). There was no difference in the time to THA between DHS and cannulated screws for femoral neck fractures. The failed fixation group had longer procedures with a mean operative time of 99.49 ± 11.80 minutes compared to 77.20 ± 7.53 minutes for the primary THA group (P <0.05). The drop in hemoglobin from preoperative to postoperative day three was greater in the failed fixation group with a mean drop of 53.52 ± 6.08 g/L compared to 43.06 ± 4.68 g/L in the primary THA group (P <0.05). The transfusion rate was 50% in the failed fixation group compared to 25% in the primary THA group (P <0.05). There was one THA revision in the failed fixation group for infection and Vancouver B2 periprosthetic femur fracture. Additionally, there was also one case of dislocation in the failed fixation group that was treated by closed reduction and did not require revision. There were no revisions or dislocations in the primary THA group. Length of admission and medical complications

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were not significantly different between the groups. The functional outcome was assessed using a standardized hip score and was found not statistically different between the groups at final follow-up (P = 0.41).

Conclusion: Conversion to THA after failed fixation of proximal femur fractures results in comparable clinical results to primary THA with an increased operative time, blood loss, and blood transfusion rate. The findings from this study support that the initial management of proximal femoral fractures by internal fixation does not negatively affect the outcomes of a salvage THA.

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.

Hip Fracture Treatment at Orthopaedic Teaching Hospitals: Better Care at a Lower Cost
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Background/Purpose: Recently, attention has been directed towards the seemingly high cost of academic medical centers compared to community hospitals for certain procedures. Few studies have examined the effect of teaching hospital status on outcomes for patients with operative hip fractures. None have excluded hospitals without orthopaedic residents from the teaching hospital designation. The purpose of this study is to examine the effect of orthopaedic teaching hospital (OTH) status, in particular, on hospital quality measures and mortality while controlling for potential confounding factors.

Methods: All isolated hip fractures admitted to a New York State hospital from 2000 to 2011 were queried from an electronic administrative database (SPARCS). Patients less than 55 years of age, those transferred from outside hospitals, and nonoperative cases were excluded. Charlson comorbidity index (CCI) was calculated to assess comorbidity burden. All orthopaedic residency programs in New York State were contacted to determine the specific hospitals that hosted orthopaedic surgery residents during the study period. These were designated as orthopaedic teaching hospitals. Multivariate, backwards-stepwise linear and logistic regression analyses were performed to determine how orthopaedic teaching hospital designation impacts in-hospital mortality, length of stay (LOS), and total hospital charges. Age, gender, race, CCI, insurance status, fracture type, trauma level, and hospital bed size were controlled for in the multivariate analysis. $P < 0.05$ was considered significant. Means are reported with ±1 standard deviation.

Results: Of the 161,080 isolated hip fractures that met inclusion criteria, 57,208 were treated at OTH and 103,872 were treated at nonteaching hospitals (NTH). Univariate analysis shows that mean total hospital charges were higher at OTH ($40,443 ± $45,753) than NTH ($31,430 ± $29,512) ($P < 0.0001$), LOS was shorter at OTH (7.99 ± 9.6 days) compared to NTH (8.09 ± 7.7 days) ($P < 0.017$) and mortality was lower in OTH (3.0%) compared to NTH (3.7%). In the multivariate total charges analysis, in addition to demographic differences, we identified total hospital beds as a significant confounding variable. For every 100 hospital beds, total charges increased 9.8% (odds ratio [OR] = 1.098, $P < 0.001$). Without controlling for hospital beds, OTH designation increases costs 19.9% (OR = 1.199, $P < 0.000001$). However, when controlling for the number of hospital beds, OTH status decreases costs by 4.5% (OR = 0.957, $P < 0.001$). Additionally, multivariate analysis found that OTH status decreased LOS by 9.1% and mortality by 24%, confirming the univariate trends.

Conclusion: While OTH may appear to have higher hospital charges for operative hip fractures, this is because they tend to be larger hospitals, which is an independent risk factor for increased charges. When controlling for hospital bed number, OTH status is associated with lower hospital charges, LOS, and lower in-hospital mortality. With the Affordable Care Act incentivizing hospital consolidation, these data suggest that increasing investment in graduate medical education programs at larger hospitals may be one strategy to achieve higher quality care at a lower cost.

See pages 47 - 108 for financial disclosure information.

Is it Safe to Operate on Therapeutically Anticoagulated Hip Fractures?

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Purpose: Delays in surgical intervention for hip fractures have been shown to increase morbidity. Therapeutic international normalized ratios (INRs) are often a reason for surgical delay. Limited data exist demonstrating that optimizing INR levels to subtherapeutic values decreases the morbidity and mortality of surgery. The purpose of this study was to compare the safety of surgical intervention in hip fracture patients with subtherapeutic and therapeutic INR values.

Methods: A multicenter, retrospective analysis was performed on prospectively collected data for a consecutive series of surgically managed hip fracture patients over a 7-year period. Exclusion criteria included patients on any anticoagulant other than warfarin or aspirin or if they had an elevated INR from an underlying medical condition. Fresh-frozen plasma and vitamin K were administered per surgeon discretion. Patients with operative INR values of 1.5 to 2.0 and 2.0 to 3.0 were compared to patients with operative INR values under 1.5 (control). The primary outcome measure was the rate of major complications (inpatient death, increased level of care, acute infection, cardiovascular event, or return to operating room [OR]). Secondary outcome measurements include all complications, the rate of blood transfusions, 30-day mortality, length of stay, and time to operative intervention from admission. A Fisher exact test was employed to test the categorical variables and t tests were used for continuous variables with statistical significance set at 0.05.

Results: 730 patients who sustained hip fractures were identified with 222 on chronic warfarin therapy. 107 patients had INR values between 1.5 and 2.0 at the time of surgery, and 84 patients had INR values between 2.0 and 3.0 at the time of surgery. 539 patients had operative INR values less than 1.5 (control). Control group demographics including age, injury, American Society of Anesthesiologists (ASA) score, and implant type were not statistically different than the therapeutic INR patients. Only length of stay was statistically different in the 1.5-2.0 group compared to the control cohort (6.65 vs 5.71 days, P = 0.039). All other measurements did not reach statistical significance (Table 1). No statistical difference was found in the 2.0-3.0 INR group compared to the control on any outcome measure (Table 2).

Conclusion: Delaying surgical intervention for an INR less than 3.0 in hip fracture patients may have limited clinical benefit. It is unclear if reversing the INR of patients on chronic anticoagulation is necessary. Expedient surgical treatment of therapeutically anticoagulated patients demonstrates no increased rate of transfusions, 30-day mortality, or complications.

	Factors[1]	Overall	Cluster 1	Cluster 2	Cluster 3
Risk[2]	Pain	4.6 (2.7)	3.3 (2.2)	5.1 (2.4)	7.1 (2.1)
	Depression	7.7 (5.9)	3.8 (3.5)	8.4 (4.0)	16.3 (4.6)
	PTSD	16.7 (14.6)	7.6 (7.3)	16.8 (9.0)	41.3 (10.7)
	Alcohol Abuse, n (%)	80 (12)	25 (8)	42 (17)	13 (12)
	Tobacco Use, n (%)	198 (29)	41 (13)	97 (38)	60 (52)
Protective[3]	Resilience	6.5 (1.6)	7.1 (1.3)	6.2 (1.6)	5.5 (1.7)
	Social Support	2.1 (1.0)	3.6 (0.7)	2.9 (1.0)	2.5 (1.3)
	Return to Work	7.2 (2.9)	9.1 (1.3)	5.9 (2.8)	5.0 (2.9)
	Manage Finance	5.9 (3.3)	8.2 (2.1)	4.0 (2.7)	3.6 (3.0)

[1] Results expressed as mean (SD), except where otherwise indicated.
[2] Ranges (clinical cut-point): Pain: 0-10 (≥5); Depression: 0-30 (≥10); PTSD: 0-68 (≥30).
[3] Ranges: Resilience: 0-8; Social support: 0-4; Return to work: 1-10; Manage finance: 1-10.

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Short vs Long Cephalomedullary Nails for Fixation of Stable vs. Unstable Intertrochanteric Femur Fractures at a Level 1 Trauma Center

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Objectives: To compare failure and complications associated with short cephalomedullary nail (SCMN) versus long cephalomedullary nail (LCMN) fixation for stable vs. unstable intertrochanteric femur fractures at a level 1 trauma center.

Design: Retrospective Cohort Study. Setting: Academic Level 1 Trauma Center. Patients/Participants: 201 adult patients with non-pathologic intertrochanteric femur fracture without subtrochanteric extension (OTA 31-A1.1-3, 31-A2.1-3, 31-A3.1-3) that were treated with a SCMN (n=70) or LCMN (n=131) between 2000-2012 and had at least 6 months follow-up. Intervention: ORIF of intertrochanteric femur fracture with either an SCMN or LCMN. Main Outcome Measurements: Treatment failure rate, defined as cutout, non-union, fracture, collapse of more than two centimeters on follow-up radiographs, or revision surgery, not including removal of symptomatic hardware.

Results: In the stable fracture group (N=81), there was no difference in failure between SCMNs and LCMNs (p=0.35). In this group, there were three failures with SCMNs (2 cut-outs, 1 collapse) and one failure with LCMN (1 cut-out). In the unstable fracture group (N=120), there was no difference in failure between SCMNs vs LCMNs (p=0.47). In this group, there were four total SCMN failures (12.9%) (1 cut-out, 2 non-unions, 1 collapse), and seven LCMN failures (7.9%) (2 cutouts, 3 non-unions, 2 collapse). There were no periprosthetic fractures in the either group.

Table 1. Failures, Complications, and Mortality in Unstable Fracture Patterns (OTA class 31-A2.1-3.3)

	Short Nail (N=44)	Long Nail (N=146)	P value	Adjusted P value	Odds/Hazard ratio (Long vs. Short)
Failure	7 (15.9%)	9 (6.2%)	0.0413[c]	0.018[log]	0.26 (0.08 ~ 0.79)[OR]
- Cut-out	2	1	--	--	--
- Non-union	3	3	--	--	--
- Fracture	0	0	--	--	--
- Collapse	0	2	--	--	--
- Revision Surgery	2	3	--	--	--
Complications	14 (31.8%)	39 (26.7%)	0.508[c]	0.282[log]	0.65 (0.3 ~ 1.42)[OR]
Mortality	20 (45.5%)	41 (28.1%)	0.03[s]	0.04[ph]	0.68 (0.47 ~ 0.99)[HR]
1 year mortality	9 (24.5%)	19 (13%)	0.22[c]	0.96[log]	1.04 (0.3 ~ 3.54)[OR]
30 day mortality	3 (6.8%)	6 (4.1%)	0.43[f]	0.61[logf]	0.67 (0.15 ~ 3.1)[OR]

[c] Chi-square test, [f] Fisher's exact test [log] Logistic regression adjusting for sex, age, Iezzoni comorbidities, days since surgery (evaluated on 12/1/2013), and tip apex distance. [s] Log-rank test comparing survivor functions,[logf] Firth logistic regression adjusting for sex, age, Iezzoni comorbidities, days since surgery (evaluated on 12/1/2013), and tip apex distance. [ph] Cox proportional hazard model comparing survivor functions adjusting for sex, age, Iezzoni comorbidities, days since surgery, and tip apex distance. [OR]: Odds ratio, [HR]: Hazard ratio

Conclusions: SCMNs and LCMNs exhibit similar failure rates in both stable and unstable intertrochanteric femur fractures.

See pages 47 - 108 for financial disclosure information.

Myth or Taboo? Use of Long-Threaded Screws in Femoral Neck Fractures

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Background/Purpose: The conventional osteosynthesis technique for these fractures is closed reduction (if necessary) and fixation with multiple cannulated screws or a sliding hip screw. The conventional technique for screw osteosynthesis of femoral neck fractures involves the insertion of cannulated screws in an inverted triangle configuration near the neck cortex without the screw thread crossing the fracture line. However, weight bearing sometimes results in significant shortening of the femoral neck and protrusion of cannulated screws, necessitating their removal because of soft-tissue irritation. We hypothesized that the use of long-threaded screws, in which the thread crosses the fracture line, would hold the thick trabeculae of the femoral neck and head together, thereby decreasing screw sliding and femoral neck shortening in 31-B1 fractures. The purpose of this study was to compare clinical and radiological results of this new osteosynthesis technique (using long-threaded screws) with those of the conventional technique (using shor- threaded screws).

Methods: We compared patients with femoral neck fractures (OTA 31-B1) who underwent osteosynthesis using three conventional short-threaded screws (Group S, n = 38) or the new technique using long-threaded screws after compression (Group L, n =38). Surgery was performed with the patient on a fracture table under general or fluoroscopy-guided spinal anesthesia. The fractures did not undergo disimpaction; however, posterior tilt of the capital fragment (apex anterior angulation) was reduced by internally rotating the leg and applying pressure from the front. Each fracture was first fixed with three 7.0-mm cannulated screws with 16-mm thread inserted percutaneously parallel to each other (within approximately 5°) without convergence or dispersion. When weakening of the lateral femoral cortex occurred, washers were used. The inferior-center screw was inserted from the lateral cortex of the subtrochanteric area, where it was not distal to the center of the lesser trochanter, and along the medial cortex of the femoral neck. The superior-anterior and superior-posterior screws were inserted to form an inverted triangle. The threads were placed in the femoral head and did not cross the fracture line. Compression was performed by tightening the cannulated screws. In Group L, the three screws were then replaced with long-threaded screws (32-mm thread) to hold the proximal and distal fragments together.

Results: Bony union occurred in all cases during follow-up (mean, 42 months). Mean screw sliding distance was 1.38 mm (standard deviation [SD], 1.77; range, 0.00-7.72) for Group L and 3.30 mm (SD, 2.81; range 0.03-12.22) for Group S (P <0.001). Mean Harris Hip Score was 90.6 for Group L and 82.6 for Group S (P = 0.001). Avascular necrosis of the femoral head occurred in one patient (2.6%) in Group L and two patients (5.3%) in Group S (P = 1.000). Results of univariate regression analysis indicated that screw sliding distance was significantly associated with age (P = 0.020) and screw type (P = 0.001). These associations were confirmed by multiple regression analysis (age, P = 0.009; screw type, P <0.001).

Conclusion: Replacement of short-threaded screws with long-threaded screws after compression provided better control of screw sliding and decreased femoral neck shortening, thereby improving functional recovery.

Table 1. Demographic and clinical characteristics of patients treated with conventional osteosynthesis using short-threaded screws and those treated with the new technique using long-threaded screws.

	Short-threaded (n=38)	Long-threaded (n=38)	p-value
Age, y	67.1±14.5	66.7±17.9	0.979
Female, n (%)	27 (71.1%)	26 (68.4%)	0.803*
Body mass index, kg/m^2	22.4±3.6	21.2±3.1	0.363
Bone mineral density, n	-2.1±1.1 (33)	-2.3±0.7 (30)	0.474
Femur neck shortening, mm	8.36±6.12	3.14±3.14	<0.001
Sliding distance of screw, mm	3.30±2.81	1.38±1.77	<0.001
Harris Hip Score	82.6±12.8	90.6±6.5	0.001
AVN, n (%)	2 (5.3%)	1 (2.6%)	1.000†
Removal of screw, n (%)	8 (21.1%)	5 (13.2%)	0.361*

Results are expressed as n (%) or mean±standard deviation. P-values were determined by Mann–Whitney U test, chi-square test,* and Fisher's exact test†

AVN: avascular necrosis of the femoral head

Table 2. Predictors of screw sliding distance.

Variable	Univariate linear regression			Multiple linear regression		
	β	SE	p value	β	SE	p value
Age	0.041	0.017	0.020	0.053	0.020	0.009
Gender	-0.307	0.633	0.630			
BMI	0.116	0.085	0.180			
BMD	0.022	0.327	0.946			
Group	-1.916	0.538	0.001	-2.080	0.538	<0.001

SE, standard error; BMI, body mass index; BMD, bone mineral density.

See pages 47 - 108 for financial disclosure information.

Percutaneous Cannulated Screw Versus Dynamic Hip Screw Fixation for Intracapsular Femoral Neck Fracture: A Comparative Study

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Background/Purpose: Choice of internal fixation for undisplaced femoral neck fractures has been a controversial topic. Historically surgeons have preferred percutaneous cannulated screws over dynamic hip screw fixation. Studies have, however, shown no significant different between the two implants. Osteosynthesis with cannulated screw fixation is a less invasive technique, with less soft-tissue stripping. However, early loosening of the screws may occur if the lateral cortex is damaged from osteoporosis. In contrast, dynamic hip screw (DHS), which is a screw-plate system with fixed angles, can achieve more stable fixation in patients with osteoporosis. However, the disadvantages of DHS technique are larger skin incisions and more soft-tissue dissection. The purpose of this study was to compare the period of union, functional outcomes, and complications of patients with femoral neck fracture treated with percutaneous cannulated screws versus DHS. This study also aimed to assess the incidence of femoral neck shortening in patients with femoral neck fractures treated with multiple cannulated screws.

Methods: This was a retrospective analysis of a prospective femoral neck fracture database to include a cohort of all patients between 1999 and 2013, with undisplaced or minimally displaced intracapsular fractures treated with either percutaneous cannulated screws (n = 120) or a DHS fixation (n = 109). All patients were followed for at least 12 months. Data were reviewed for failure of the implant with radiographic evidence and the cause for revision documented. The latest AP radiograph of the fractured hip was compared with that of the contralateral uninjured hip for femoral neck shortening using the electronic images on the PACS (patient archiving and communication system).

Results: A total of 229 patients, with 109 in the percutaneous cannulated screw group and 120 in the DHS fixation group, were assessed. Both groups were similar in respect of injury mechanisms, injury-surgery interval, gender, and age (all P values = 0.29). In the cannulated hip screw fixation group there were 11 revisions surgeries compared to 4 in the DHS group ($P < 0.05$). Indications for revision included progression of osteoarthritis (n = 1), early failure of metal work (n = 1), and osteonecrosis (n = 9)(in the cannulated screw group. In the DHS group, indications for revision included osteoarthritis (n = 1) and osteonecrosis (n = 3). The shortening of femoral neck did not show significant difference in the two groups.

Conclusion: In our study, there was increased risk of osteonecrosis and failure in cannulated screw fixation group compared to the DHS fixation in the management of undisplaced femoral neck fracture. In conclusion, although DHS fixation requires a larger skin incision and more soft-tissue dissection, its use in elderly patients with osteoporosis is preferred due to its simplicity, efficacy, and high overall success rate.

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Relationship Between the Charlson Comorbidity Index and Cost of Treating Geriatric Hip Fractures: Implications for Bundled Payment

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Background/Purpose: In the last decade, the incidence of hip fractures has dramatically increased, largely due to an aging population. With current costs of treating a hip fracture on the rise, a bundled payment system has been proposed to contain costs by paying hospitals and physicians a single amount for the treatment of a single injury. Prolonged hospital length of stay (LOS) has been identified as a major driver for costs in hip fracture surgery, but few studies have investigated potential predictors of LOS in patients with these injuries. The Charlson Comorbidity Index (CCI), a validated predictor of mortality based on comorbidities, succinctly summarizes a patient's overall health status with a score ranging from 0 (no risk) to 35 (severe risk). The purpose of our study was to assess if a patient's CCI score could utilized as a tool to predict LOS in geriatric hip fracture patients.

Methods: Through a retrospective chart analysis, patients over 60 years of age presenting with a low-energy hip fracture to a Level I trauma center from January 2000 to December 2009 were identified. Types of surgery included total hip arthroplasty (THA), hemiarthroplasty (hemi), cephalomedullary nailing (CMN), open reduction and internal fixation (ORIF), or closed reduction and percutaneous pinning (CRPP). Data were collected on LOS, age, gender, and comorbid conditions, from which the CCI was calculated. Linear regression analysis was used to evaluate statistical significance of the impact of surgery type on LOS, after controlling for age, gender, and CCI score. Inpatient financial services provided the estimated cost of an inpatient stay ($4530/night).

Results: Of the 720 charts reviewed, 615 patients met inclusion criteria and were included in analysis. After controlling for age, gender, American Society of Anesthesiologists score, body mass index (BMI), race, smoking status, and anesthesia type with linear regression analysis, patients with an increased CCI score had a statistically significant increased LOS ($P = 0.014$). Compared to patients with a CCI of 0, patients with a CCI score of 1 stayed an average of 0.7 days longer and incurred $4303.50 more in costs. Patients with a CCI score of 2, on average, had an increased LOS of 1.92 days compared to a patient with a CCI of 0, and incurred $8697.60 in additional costs.

Conclusion: This is the first study to demonstrate the value of using CCI as a predictor for LOS in geriatric hip patients. The higher CCI scores were shown to correlate with prolonged LOS following treatment for a hip fracture, and subsequently higher hospital costs. This study suggests that the CCI score may be utilized as a valuable tool to predict resource utilization in patients with geriatric hip fractures.

See pages 47 - 108 for financial disclosure information.

Relationship between the Charlson Comorbidity Index and Cost of Treating Geriatric Hip Fractures: Implications for Bundled Payment

Figure 1: Mean length of stay per CCI

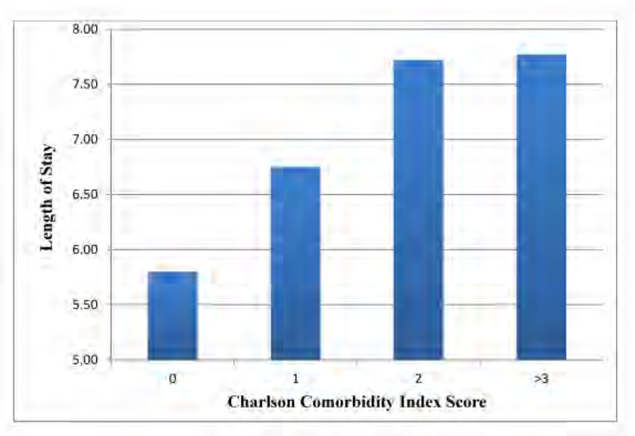

Figure 2: Mean cost of stay per CCI

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.

Missing Data May Invalidate Hip Fracture Database Studies

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Purpose/Background: National databases are increasingly being used for research in orthopaedics, as they offer significant power for analyses. However, these databases have significant limitations. One limitation that has received sparse mention in the literature is the prevalence of missing data. Studies using these databases often do not mention the percent of missing data for each variable used, and do not make note of how patients with missing data are incorporated into analyses. This study uses the American College of Surgeons National Quality Improvement Program (ACS-NSQIP) database to illustrate how different treatments of missing data can significantly skew results.

Methods: Patients who underwent hip fracture surgery between 2005 and 2013 were identified from the ACS-NSQIP database using Current Procedural Terminology (CPT) codes. Demographics, comorbidities, and type of procedure were tabulated for each patient and the percent of missing data was noted for each variable. These variables were tested for association with "any adverse event" using two separate multivariate regressions that used the two most common treatments for missing data. In the first regression, patients with any missing data were simply excluded. In the second regression, missing data were treated as a negative, or "reference" value. The results of these regressions were compared in order to determine how the different treatments of missing data can affect the results of hip fracture studies using the ACS-NSQIP database.

Results: A total of 26,066 hip fracture patients were identified. The average age was 80.1 ± 10.9 years (mean ± standard deviation). The following rates of missing data were found for each demographic category: 0.00% for age, 0.05% for sex, 12.25% for body mass index (BMI), and 18.19% for race. The rate of missing data was 70.94% for each of the following comorbidities: alcohol use, pneumonia, esophageal varices, history of myocardial infarction, previous percutaneous coronary intervention, previous cardiac surgery, angina, peripheral vascular disease, rest pain, impaired sensorium, coma, hemiplegia, history of transient ischemic attack, stroke with/without neurologic deficit, central nervous system tumor, quadriplegia, chemotherapy, and radiotherapy. Multivariate logistic regressions for the association of demographics, comorbidities, and procedure characteristics with any adverse event within 30 days of surgery were performed with the two most common techniques for handling missing data: excluding patients with missing data, and treating missing data as the negative, or "reference" value. As seen in Table 1, these different techniques lead to finding vastly different significant risk factors for adverse events on multivariate analysis. Out of 17 risk factors found to be significantly associated with adverse events in either analysis, only six of these risk factors were common between the two regressions.

Conclusion: This study illustrates that a significant amount of missing data can be found in a hip fracture sample drawn from the ACS-NSQIP and extreme caution needs to be taken when selecting variables for inclusion in analyses. Specifically, 19 comorbidity variables have

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70.94% missing data, as they are now only collected at certain ACS-NSQIP participating sites. This is not made clear in the basic participant user manual distributed with the data set and researchers must be diligent when using data from more recent years. In addition, as shown in this sample, the treatment of missing data can significantly affect the results of hip fracture studies performed with this data set. There are multiple studies in the literature that have used this cohort of hip fracture patients in the ACS-NSQIP, and the majority of these studies fail to comment on the amount of missing data or how it was treated in analyses. This study raises significant questions about the validity of these studies and it is important for researchers to be aware of the limitations of databases when designing, performing, and evaluating such investigations. It is critical that studies using these data sources report how missing data are handled.

Table 1. Results of multivariate analysis for any adverse event with differing treatments of missing data.

	After excluding patients with missing data (n=5,760)		Missing data treated as negative (n=26,066)	
Risk Factor	OR	P-value	OR	P-value
Cerebrovascular accident	1.4	0.021	1.4	0.003
Preoperative pneumonia			1.9	0.010
Angina			2.0	0.001
Impaired Sensorium			1.4	0.020
Age 70-79 vs age < 50			1.7	0.003
Age 80-89 vs age < 50			2.0	<0.001
Age 90+ vs age < 50			2.4	<0.001
BMI 25-30 vs BMI <25			0.9	0.023
BMI 35+ vs BMI <25			1.2	0.030
Native American or Pacific Islander vs White race	2.6	0.042		
Male sex	1.2	0.038	1.2	<0.001
ASA 3 vs ASA 1-2	2.2	<0.001	1.8	<0.001
ASA 4+ vs ASA 1-2	3.6	<0.001	3.0	<0.001
Procedure type (vs percutaneous pinning)				
Hemiarthroplasty	1.5	0.005	1.5	<0.001
Primary total hip arthroplasty			1.6	<0.001
Plate/screw			1.3	0.009
Intramedullary nail	1.4	0.020	1.4	0.001

OR = odds ratio; BMI = body mass index; ASA = American Society of Anesthesiologists.

Topical Vancomycin Powder Decreases the Incidence of *Staphylococcus aureus* Infections in Operatively Treated Fractures

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Purpose: Topical vancomycin powder has demonstrated efficacy in decreasing infections in multiple retrospective spine surgery studies, but has not yet been examined in orthopaedic trauma surgery. Our primary hypothesis was that topical vancomycin powder will decrease the rate of *Staphylococcus aureus* infections in operatively treated fractures. Our secondary hypothesis was that topical vancomycin powder would decrease the surgical site infection rate in "high-risk" operatively treated bicondylar tibial plateaus, pilons, and calcanei.

Methods: We retrospectively reviewed all fracture fixation cases at one academic medical center that were treated with topical intrawound vancomycin powder. The study group was 91 patients with 99 distinctive injuries treated between October 2012 and November 2014. Deep infections were defined by CDC (Centers for Disease Control and Prevention) criteria and all had positive intraoperative cultures. Our baseline rates of S. aureus were determined from a recently published control group (n = 214) at the same institution prior to use of vancomycin powder. Our baseline rate of deep infection in high-energy pilon, plateaus, and calcanei was also determined from a recently published control group (n = 116) at the same institution. Fisher exact test was used to compare categorical values.

Results: The rate of S. aureus was significantly lower in patients receiving vancomycin powder cohort than the cohort of infections before vancomycin powder was used (12.5% [1 of 8] vs 58% [124 of 214], P = 0.03). A trend was observed for a lower rate of methicillin-resistant S. aureus (0% vs 32%, P = 0.06). We observed a lower infection rate in the 34 calcaneus, pilon, and/or plateau fractures treated with vancomycin powder than in the control group of patients prior to use of vancomycin powder (0% vs 13%, P = 0.02).

Conclusion: Our data demonstrate that vancomycin powder may alter the bacteriology of surgical site infections and perhaps lower the rate of surgical site infection. Although our results are statistically significant (P <0.05) these findings must be confirmed in larger randomized controlled trials. These initial data do present provocative evidence that vancomycin powder may have an important role in our attempts to prevent the devastating complication of surgical site infection after fracture fixation surgery.

See pages 47 - 108 for financial disclosure information.

Topical Antibiotics for Infection Prophylaxis in Pelvic and Acetabular Surgery

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Background/Purpose: Application of topical antibiotics (TA) has been shown to reduce surgical site infection (SSI) in spine surgery. The purpose of this study was to determine if TA (vancomycin and tobramycin) reduces the incidence of SSI in open pelvic and acetabulum surgery. The authors hypothesize that TA will reduce incidence of infection without increasing incidence of renal failure.

Methods: A retrospective case control study of patients at a Level I trauma center undergoing operative fixation of the pelvis ring and acetabulum from March 2012 to November 2013 was conducted. Group 1 (10 months) had no topical antibiotics, and Group 2 (10 months) had TA applied to surgical site at time of closure. Statistical significance was determined using Fisher exact test and Student t test with P <0.05. Univariate logistic regression determined effect of each covariate on the risk of infection with odds ratio P <0.05.

Results: 153 patients were included. Group 1 (n = 75) and Group 2 (n = 78) were statistically similar for sex, age, ethnicity, and body mass index (BMI). The odds of infection for the non-vancomycin group were 3.52 times that for Group 2 (P = 0.037). Blood transfusions and intraoperative blood loss were also significant predictors of infection (P = 0.029 and <0.001, respectively). There were no adverse clinical outcomes from administration of topical antibiotics.

Conclusion: Topical antibiotics reduced the incidence of SSI following open pelvic and acetabulum fixation without increasing risk of renal failure. Increasing blood transfusions and intraoperative blood loss were associated with increased risk of infection.

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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.

Δ Vancomycin Powder Reduces Infection in an Open Fracture Model

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Background/Purpose: Use of locally applied vancomycin powder as a surgical adjunct to decrease surgical site infections has garnered increased attention in the spine literature where its use led to a 4-fold decrease in deep infections. The impact of this on the orthopaedic trauma community is largely unknown because spine infections are generally considered surgical site infections where bacteria are introduced at the time of surgery. However, open fractures are often contaminated at the time of injury, followed by early surgical intervention. Traditionally, a delivery device, such as polymethylmethacrylate (PMMA), has been used for local antibiotic application as it elutes antibiotic over time, but this requires an additional procedure for removal. The use of vancomycin powder allows for local antibiotic application that can be distributed throughout the wound and cleared by the body without the need for surgical removal. However, there is concern that its potential rapid disappearance from the wound would make it less effective in the setting of an open fracture. The purpose of this study was to determine if locally applied vancomycin powder in an established contaminated rat femoral defect model would decrease the incidence of infection.

Methods: Critical size (6 mm) defects were created in 40 Lewis rat femurs and supported by a polyacetyl plates and threaded Kirschner wires. Each animal was inoculated with 105 colony-forming units (CFU) of UAMS-1, a Staphylococcus aureus osteomyelitis isolate, at the time of surgery via a collagen matrix. The animals were then assigned to one of three groups: debridement and irrigation (D&I) without local antibiotics (Standard Treatment), D&I with vancomycin-loaded (10% wt/wt) PMMA beads (Vanc Beads), or D&I with 50 mg local vancomycin powder (Vanc Powder), which is a sufficient application to coat the entirety of the wound bed prior to closure. They were randomized for treatment at either 6 or 24 hours postinoculation, when the wound was then reopened, debrided, and irrigated with saline and the treatment applied. Every animal received 72 hours of twice daily cefazolin (5 mg/kg) beginning at the time of debridement. Serum antibiotic levels were measured at 24 hours, 7 days, and 14 days. All animals survived for 14 days post treatment. Following euthanasia, bacteria were quantified and local inflammatory markers (interleukin [IL]-6, TNFα [tumor necrosis factor alpha], and RANTES) were measured.

Results: Locally applied vancomycin powder effectively reduced bacteria both within the bone (Figure 1A) and on the hardware (Figure 1B) when treatment was not delayed ($P<0.001$). Furthermore, there were similar results for the Vanc Powder and Vanc Beads groups at both time points. Interestingly, neither of the local antibiotic strategies reduced infection rates when treatment was delayed until 24 hours. The inflammatory markers corresponded with the bacteria levels in all groups at each treatment time point (data not shown). Vancomycin was detectable in the blood of all Vanc Powder animals at 24 hours post administration with an average of 10.30 μg/mL. At 7 days, the serum antibiotic levels averaged 0.13 μg/mL and were present in only 30% of Vanc Powder animals. By day 14, only 20% of Vanc Powder

Δ OTA Grant

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animals had detectable serum levels of antibiotic, averaging less that 0.05 μg/mL. At each time point there was no vancomycin detectable in the serum of the Vanc Beads animals.

Conclusion: This study suggests that vancomycin powder is a promising adjunctive therapy for preventing infection in traumatic wounds if treatment is not delayed. This time-dependent effectiveness of vancomycin powder is similar to what has been observed with both systemic and other local delivery adjuncts due to rapid biofilm formation occurring within a few hours of contamination, making the bacteria recalcitrant to antimicrobials. Similar to what has been reported by the spine community, vancomycin powder may be particularly useful for infection prevention when used in early primary closure of traumatic wounds.

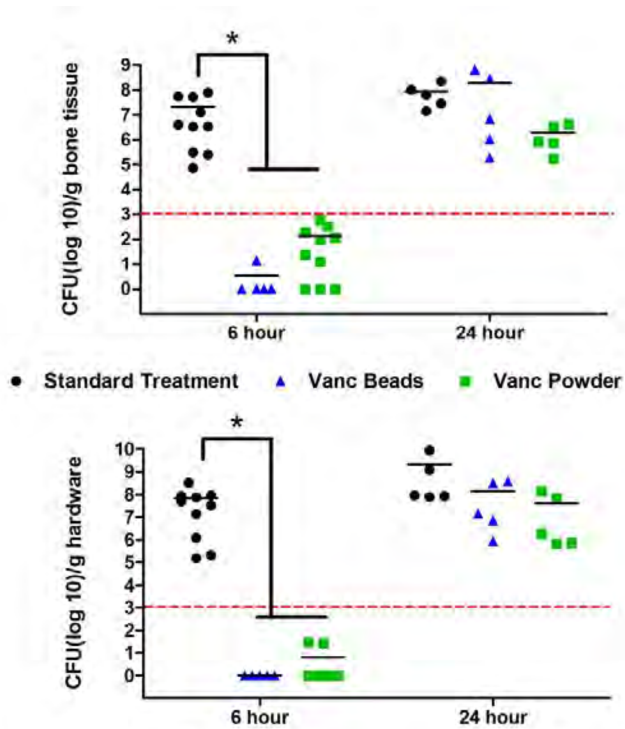

Figure 1. Effect of vancomycin treatment type and time on limb infection. (A) Bacterial count within the bone; (B) Bacterial count on the hardware. Significant difference between those infected (CFU > 10^3) and not infected (CFU < 10^3)(red line) at 6 hours (P<0.001) but not at 24 hours (p=1) (Fisher's Exact Test)

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.

Open Ankle Fractures: What Predicts Infection?

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Purpose: Data on the complication rates of open ankle fractures are from small data sets or aggregate data that lack precision and detail. The purpose of this study was to identify the patient, injury, and treatment factors associated with infection of open ankle fractures in a large data set generated from individual chart reviews.

Methods: We reviewed the records of a consecutive series of patients presenting to 13 trauma centers with open indirect ankle fractures. Patients with plafond injuries were excluded. We gathered demographic information including: age, gender, BMI (body mass index), smoking history, diabetes, immunosuppressive medications, neuropathy, and OTA fracture type; and treatment variables including: timing and duration of antibiotics, timing of debridement, and method of closure. Infection was defined two ways: first as the combination of superficial or deep purulence, and second with the addition of wound dehiscence. Statistical comparisons were made using Fisher exact and Student t tests for categorical and continuous data.

Results: We reviewed 613 patients, (312 male, 301 female) aged 18-96 years (average 52) with an average BMI of 32 who sustained OTA types 44A (11%), 44B (60%), and 44C (29%) open ankle fractures; 433 (72%) were dislocated upon presentation. Average follow-up was 392 days. There were 95 patients with diabetes, of whom 31 were insulin dependent and 37 had documented neuropathy. 22 patients were on immunosuppressive medications. 226 patients (41%) were smokers. Increased BMI, OTA type, immunosuppressive medications, or presence of dislocation were not significantly associated with infection ($P > 0.05$). The overall infection rate in the series was 12% and rose to 17% when including wound dehiscence. Diabetes was associated with an increased risk of infection (24%; $P = 0.0006$) and was 32% when including wound dehiscence ($P = 0.0002$). Smoking ($P = 0.04$) and increasing Gustilo

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type (P = 0.005) also correlated with infection. The table details the rates of infection by open fracture type. Initial antibiotics were given within 6 hours in 86% and 12 hours in 94% and neither cutoff was associated with infection. There was no difference in the average time to antibiotic administration for those who developed infection versus those who did not (3.8 hours vs 3.7 hours; P = 0.95). The time to initial debridement tended to be longer for those who developed purulence (P = 0.15). Debridement at >6 hours (17% vs 9%; P = 0.03) and >12 hours (21% vs 11%; P = 0.003) after injury was associated with infection. Cases that developed infection were closed at an average of 14.2 days versus 3.3 days for those that did not become infected (P = 0.004). Primary and delayed primary closure was achieved in 93% of cases. Primary closure resulted in a lower rate of infection (P = 0.006). Overall there were 51 cases of malunion, nonunion, and loss of reduction. Infection resulted in a higher rate of these complications (P = 0.02).

Conclusion: In this large series of open ankle fractures, several patient and injury factors were found to be associated with infection and wound breakdown including diabetes, smoking, and increasing severity of open fracture. We found no association between the timing of initial antibiotics, but all centers were efficient and 86% were given antibiotics within 6 hours of injury, limiting our ability to evaluate this as a factor. However, debridement after 6 hours and 12 hours demonstrated incremental increases in infection rates. Finally, a shorter time to wound coverage and the ability to close the wound primarily were associated with a lower risk of infection.

Open Ankle Fractures: What Predicts Infection?

Table: Infection including wound dehiscence by Gustilo type

Gustilo Type	**1**	**2**	**3A**	**3B,C**
% Infection	**6%**	**15%**	**18%**	**36%**

Risk Factors vs. Infection			
NOT Associated with Infection		Associated with Infection	
Factor	P Value	Factor	P Value
BMI	0.22	Diabetes	0.0002
OTA Classification	0.81	Smoking	0.04
Dislocation	0.07	Gustilo Type	0.005
Immunosuppressive Meds	0.18	Time to Debridement	0.02
Time to Antibiotics	0.88	Time to Closure	0.004

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.

Fracture Union Following Infected Hardware Fixation: A Prospective Population-Based Cohort Study

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Purpose: Orthopaedic devices are increasingly used for internal fixation of fractures. Approximately 5% of initially inserted internal fixation devices become infected, frequently leading to delayed fracture union, high morbidity, and significant mortality. Standard orthopaedic treatment involves antimicrobial therapy combined with surgical debridement and/or primary removal of infected hardware. Management remains a clinical dilemma, particularly regarding the need for primary device removal, as scant literature is available to aid decision making. The primary aim of this study was to determine the overall rate of fracture union following infected fracture fixation with combined orthopaedic and infectious diseases (ID) management.

Methods: 93 consecutive patients with infected hardware following fracture fixation referred by the orthopaedic service to the ID service for combined management were enrolled. Demographic information, fracture characteristics and fixation dates, time to fracture union, and details regarding infecting organism and antimicrobial therapy for every patient enrolled were entered into a computerized database in real time. Clinical assessment, medical records, and radiographs were reviewed to determine time to radiographic and clinical union. Non-normal numerical data was summarized by median and semi-interquartile range (SIQR). Survival analysis techniques were used to describe the time to union and assess its relationship to the initial surgical management and other factors. P values were calculated using Peto-Peto-Prentice test.

Results: 70 males and 23 females with a median age of 44 years (SIQR 13.5) met the inclusion criteria. Of these, 65 lower limb and 26 upper limb fractures were identified. 26 (28%) were open fractures. Methicillin-sensitive Staphylococcus aureus (MSSA) (58%) was the most frequent infecting organism, followed by methicillin-resistant S. aureus (MRSA) (12%), gram negative (9%), and other gram positive (4%) bacteria. A mixed growth of organisms not including MRSA or MSSA represented 2%, while no organism was identified in 15% cases. The median duration of IV antibiotics was 42 days (SIQR 5.5 days). Overall 82% of patients achieved union at 2 years following initial fracture fixation (Figure). Fracture union was achieved in 68 of 82 (83%) patients treated with initial hardware retention and 9 of 11 (82%) who underwent immediate removal of hardware at time of infection. The difference was not significant (P = 0.91). Median time from first fracture fixation to union was 267 days (SIQR 202). Fracture union did not vary between upper (median 227 days; SIQR 154) and lower (median 286; SIQR 369) limb fractures (P = 0.19).

Conclusion: Fractures with infected hardware requiring long-term antibiotic therapy, combined with management from a dedicated ID service, can expect a union rate of 82% at 2 years following initial fracture fixation. Differences in union rate were not observed between immediate hardware retention/removal or upper/lower limb fractures.

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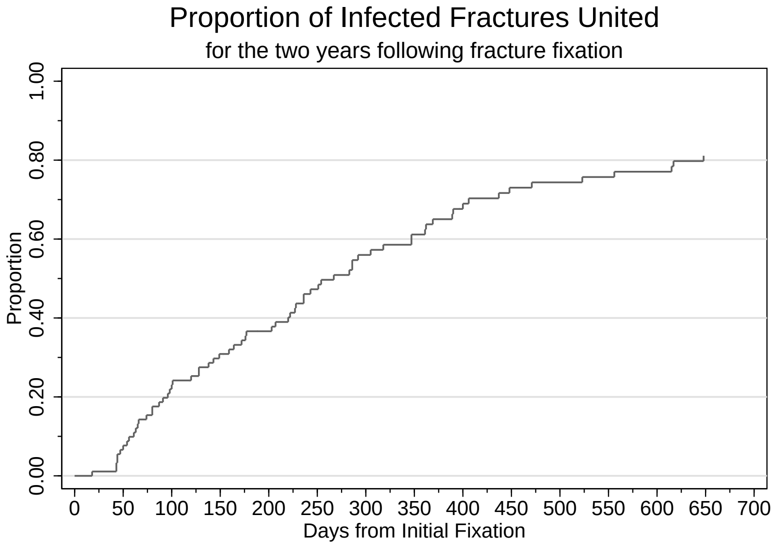
PAPER ABSTRACTS



PAPER ABSTRACTS

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.

Correlation Between Routine Microbiology Results at Definitive Closure and Wound Infection in Type III Tibia Fractures: Results from a Multicenter, Prospective Cohort Study

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Purpose: Infection remains the most common and significant complication following high-energy fractures. However, we are currently unable to assess the relationship of a subsequent deep infection to the patient's bioburden profile at the time of wound closure and are unable to determine the efficacy/impact of the patient's antibiotic treatment during the hospitalization to the late infection pathogen. The goal of this analysis is to examine the correlation between routine microbiology results at the time of soft-tissue closure with subsequent wound infection.

Methods: Participants (N = 509) with open Gustilo Type III tibia fractures or traumatic amputation were recruited across 33 Level I trauma centers and followed for 6 months following definitive soft-tissue closure. Debrided tissues and swabs collected at the time of the soft-tissue closure were sent for routine microbiology at a central laboratory. Subsequent infections were diagnosed following CDC (Centers for Disease Control and Prevention) criteria, and microbiology results provided by the local hospital laboratories following standard of care procedures. Participants were 71% male, 63% white, 81% polytraumatized, and had a mean age of 39.2 years. Bivariate analyses and multivariate regression techniques were used to examine the relationship between routine microbiology results at baseline and subsequent infection. Bivariate analyses were conducted for 452 participants with baseline microbiology data and regression analyses were performed for 426 records with complete data for outcomes and all covariates.

Results: The overall infection rate was 13.2% (56 of 426). Among 347 participants with negative microbiology results at baseline, the 6-month infection rate was 11.2% (39 of 347). Among 105 participants with positive routine microbiology results at baseline, the infection rate was 19.1% (20 of 105). After adjusting for confounders (polytraumatized, traumatic amputation, smoking status, and wound contamination), participants with positive baseline microbiology results were twice as likely to come back with an infection (odds ratio [OR]: 1.92; 95% confidence interval [CI]: 1.06, 3.50; P = 0.032). Both the presence of surface and imbedded wound contamination noted at the initial debridement (as defined by the Orthopaedic Fracture Classification) were also predictive of infection (ORs of 2.13 and 2.41, respectively; P <0.05 for both). Overall, the percent of positive baseline routine microbiology species matching the species identified at the subsequent infection was 26.9%. The three most common species identified at soft-tissue closure were Enterobacter cloacae, Enterococcus species, and Serratia marcescens, with 3/7, 2/6, and 2/6 returning with subsequent infection with that particular species, respectively. However, by far the most common follow-up infectious species was Staphylococcus aureus, which comprised 30% of infectious species identified (roughly equally split between MRSA [methicillin-resistant S. aureus] and MSSA [methicillin-sensitive S. aureus]), but was only observed in 3 baseline microbiology results, none of which matched to subsequent infections. Interestingly, among participants with

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positive microbiology results at baseline, S. aureus was not a top five species in infected follow-up microbiology results. Instead, Enterobacter species was the most commonly observed, comprising 22% of infectious species identified among participants with positive routine microbiology results at baseline.

Conclusion: Overall, we document a moderate correlation between bioburden (as measured by routine microbiology) at the time of soft-tissue closure and subsequent infection. However, the relationship between pathogens at these time points was weak, with the most common infectious pathogen, S. aureus, being nearly absent in baseline routine microbiology results. This could be related to the perioperative antibiotic selection and short-term suppression, or high biofilm production. The results highlight the limitation of routine microbiology results, and suggest further advancement in this area will require the use of more advanced tools for baseline microbial bioburden identification. Identification of bacteria responsible for late infections is a critical next step to assess the potential of novel local and/or systemic antibiotic strategies.

Culture-Negative Infection After Traumatic Injury

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Background/Purpose: The diagnosis and treatment of infection associated with orthopaedic implants is a challenge. Clinicians make these diagnoses based on a combination of clinical presentation, laboratory studies and bacterial culture. Identification of the primary pathogen directs antibiotic regimen. Definitive culture growth is the primary method by which we determine the pathogen. However, this traditional approach often results in false positives (contaminants, but not pathogens) or false negatives (either previous treatment with antimicrobials or fastidious pathogens), both of which result in a clinical dilemma. False negatives are particularly problematic in patients with clear clinical signs of infection. This relatively common clinical scenario is the impetus to our study question: do culture-negative infections behave differently than infections with an identifiable pathogen? The purpose of this study was to compare outcomes of patients with culture-negative infections to those with culture-positive infections. Furthermore, we sought to identify the incidence and describe the common characteristics of culture-negative infections in patients who sustained traumatic injuries that required surgical stabilization/fixation.

Methods: Patients treated for surgical site infection at two Level I trauma centers were retrospectively identified. 392 patients between January 2007 and December 2013 met inclusion criteria. Inclusion criteria consisted of patients who underwent operative irrigation and debridement (I&D) for a surgical site infection after having undergone fixation of an open or closed fracture. Patients who underwent arthroplasty for primary fracture treatment were excluded. Infection was defined as erythema and/or purulent drainage presenting after definitive wound closure necessitating return to the operating room for I&D, as indicated by the responsible surgeon. The primary outcome measures were successful eradification of infection and time to fracture union. Secondary outcome measures included need for subsequent operative procedures. Cultures were taken at the time of index I&D. Antibiotic therapy was initiated with consultation by an infectious disease specialist.

Results: The overall rate of culture negative infection was 9% (34 of 392). An additional 8% (31 of 392) grew positive bacterial culture from broth only, which may represent contaminants rather than infecting pathogens. There were no significant differences between the two groups with regard to treatment failure, time to union, and need for subsequent procedure. 34% of culture-positive infections were treatment failures and 38% of culture-negative infections were treatment failures (P = 0.13). Time to union among culture-positive infection was 22 weeks and among culture-negative infection was 24 weeks (P = 0.185). 30% of patients with culture-positive infection required subsequent procedure (including amputation, arthrodesis, arthroplasty, girdlestone, soft-tissue reconstruction) and 35% of patients with culture-negative infection required similar secondary procedures (P = 0.6608).

Conclusion: To our knowledge, this is the first study evaluating culture-negative infection in the orthopaedic trauma literature. This remains a treatment dilemma that is encountered frequently, in nearly 10% of infections in this study, but has been poorly addressed in the

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literature. This study found no difference between patients with positive intraoperative cultures and those with negative intraoperative cultures with regard to success of treatment, need for subsequent procedure, or time to union. This suggests that current empiric therapy for negative intraoperative cultures is as effective as microbe-specific therapy.

Can MRSA Screening Swabs Help Predict Risk of Postoperative Infection Following Open Fracture Treatment?

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Background/Purpose: Postoperative infection following open fracture of an extremity can result in significant morbidity including further surgical intervention, increased length of stay, extended use of antibiotic therapy, and even limb loss. Standard antiSbiotic prophylaxis for open fractures (cefazolin) covers Staphylococcus species, but does not offer prophylaxis against methicillin-resistant Staphylococcus aureus (MRSA). Our hypotheses were: (1) open fractures in patients with MRSA positive nasal swabs will have higher overall infection rates; (2) in patients colonized with MRSA, there would be higher rates of MRSA infections.

Methods: We conducted a retrospective review of all patients undergoing surgical treatment of open fractures between 2008 and 2012 at single urban academic medical center. Data collected included: age, demographics, mechanism of injury, type of fracture, time to operation, perioperative antibiotics, outcomes, and intraoperative cultures (in cases of infection). Results of preoperative screening exams, including nasal swabs for MRSA, were also collected. At this center cefazolin was routinely used as prophylaxis at the time of surgery as well as on initial presentation to the center. Clindamycin was utilized in penicillin-allergic patients. No patients received perioperative MRSA coverage (vancomycin) regardless of nasal swab result. Patients without an available admission swab were excluded. Surgical site infection was defined as an infection that was treated with operative debridement. Data were analyzed using Fisher exact test.

Results: 1327 open fractures were screened; 193 developed postoperative infections (21%). Of these, 907 open fractures had available MRSA screening swabs comprising our study group. Fractures that did not have MRSA swab data were excluded (420) accounting for 16 infections (3.8% infection rate). Of the study group (n = 907) a total of 864 were MRSA swab negative and 43 MRSA swab positive. Postoperative infections were identified in 193 (21% of fractures) of the 907 for whom screening swabs were available. MRSA positive nasal swabs had a higher rate of postoperative infection (35% [15 of 43] vs 21% [178 of 864]; P = 0.0344). Of those with MRSA-positive swabs, MRSA infection was identified 6/15 versus 29/178 in those who were MRSA swab negative (40% vs 16.2%, P = 0.03). Of the MRSA swab positive group, 60% (9/15) developed a postoperative infection with Staphyloccus species, 67% (6/9) of which were MRSA.

Conclusion: In our data set, a positive MRSA nasal swab on admission was associated with an increased risk of developing a postoperative infection (P <0.05). Previous work

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has identified positive MRSA swabs as a risk factor for surgical site infection, but to our knowledge this is the first analysis that has demonstrated a similar risk for infection after open fractures. The etiology of this increase is not currently known, in light of the fact that most patients with MRSA positive swabs become infected with an organism other than MRSA (60%). It raises the question whether MRSA positivity is a marker for increased risk of infection. Prospective studies are warranted to investigate if changes in antibiotic prophylaxis or decolonization methods can affect infection rates.

Vancomycin and Cefepime Antibiotic Prophylaxis for Open Fractures Reduces the Infection Rates in Grade III Open Fractures Compared to Cefazolin and Gentamicin, Avoids Potential Nephrotoxicity, and Does Not Result in Antibiotic Resistance with MRSA

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Background/Purpose: Historically, Cefazolin with or without Gentamycin has been used for prophylaxis against post-traumatic infection after open fractures. While S. Aureus (SA) has traditionally been the most prevalent causative organism, there has been a notable increase in the prevalence of methicillin-resistant S. Aureus (MRSA). The purpose of this analysis is to report on the results of a new antibiotic prophylaxis regimen at a single institution using Vancomycin and Cefepime for open fractures.

Methods: Retrospective review of all patients requiring operative management of open fractures at a single institution between 2008 and 2013. Group 1 (CG) patients (2008-2010) received cefazolin and gentamicin as antibiotic prophylaxis for open fractures. Group 2 (VC) patients (2011-2013) received vancomycin and cefepime as antibiotic prophylaxis for open fractures. Patients not receiving their initial treatment at this institution were excluded from the analysis. Hospital records were reviewed to collect data regarding the nature of injury, grade of open fracture, and type of prophylactic antibiotic administration. Microbiology records were analyzed for the causative organisms for each patient who subsequently developed an infection, as well as the minimum inhibitory concentration (MIC) for vancomycin in MRSA cases we identified from year to year, looking for increased antibiotic resistance.

Results: There were 37 infections (5.5%) after 670 open fractures in group CG and 35 infections (4.0%) after 869 open fractures in group 2 VC (p=0.18). For open grade III, CG yielded an infection rate of 6.8% whereas the infection rate for VC group was 3.1% (p=0.03). Similar infection rates were seen in open grades I and II. Polymicrobial infection was found to be present in 48.6% (n=18) of all infection in CG group, and 28.5% (n=10) in VC group (p=0.22). Staphylococcus aureus remained the most prevalent pathogen isolated in open fractures in both groups. Eight of 37 (21%) infections in CG, and 8 of 35 (23%) infections in VC were positive for MRSA (p=1). Ten of 37 (27%) infections in CG, and 8 of 35 (23%) infections in VC were Methicillin Susceptible Staphylococcus Aureus (MSSA) (P=0.78). There were statistically more infections in CG group with Enteroccocus (6 CG, 0 VC) (P=0.02) and Pseudomonas (9 CG, 2 VC) (P=0.04). Acute kidney injury was not seen in any patient with normal renal function at admission (P=1). Minimum inhibitory concentration for Vancomycin for all patients with MRSA infection remained less than 1 for each of the six years evaluated, even after transition to vancomycin and cefepime.

Conclusions: Vancomycin and Cefepime regimen is superior to Cefazolin and Gentamicin for infection prophylaxis in Grade III open fractures. Vancomycin and Cefepime did not significantly decrease the incidence of polymicrobial infections after open fracture, but there was certainly a trend towards reduction. Forty-eight hours of antibiotic prophylaxis does not seem to affect renal function in patients with normal creatinine levels at the time of admission, regardless of the class of antibiotic employed. Vancomycin can be safely used for coverage of gram positive organisms without an increase in antibiotic resistance.

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A Supply and Demand Analysis of the Orthopaedic Trauma Surgeon Workforce in the United States

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Background/Purpose: The number of orthopaedic trauma surgeons (OTS) is increasing in the United States. Recent works have highlighted a growing concern among new orthopaedic trauma graduates over the availability of trauma-only positions, as well as the ability for OTS to develop expertise to properly care for complex injuries due to dilution of case volume. Additional effects include the potential impact on education due to decreased volume at training programs, and financial effects on OTS in the current fee-for-service reimbursement system. Increases in the US population correspond with increased trauma; however, it is not known whether the rate of increase in orthopaedic trauma injuries matches the rate of increase in the number of OTS. The purpose of this study is to investigate recent trends in orthopaedic trauma and to assess whether the increased supply of OTS matches with increased demand for their skills. We hypothesized that the supply of OTS has increased at comparatively faster rate than demand from 2002-2012.

Methods: Supply of OTS was estimated using OTA membership data (active, clinical, associate) as a surrogate. The annual number of operative pelvis and acetabulum fractures reported by American College of Surgeons (ACS)-verified trauma centers in the National Trauma Data Bank (NTDB) was used as a surrogate of demand for OTS. International Classification of Diseases, Ninth Revision (ICD-9) diagnosis and procedure codes were extracted from the NTDB. Cases were included only when both ICD-9 diagnosis and procedure codes for pelvis and acetabular trauma were present, in order to capture only operative injuries. Because surrogates were used to estimate supply and demand, the annual rate of change in OTA membership versus rate of change in operative injuries per NTDB center was compared.

Results: From 2002-2012, overall reported operative pelvis and acetabular injuries increased by an average of 21.0% per year. The number of reporting trauma centers increased by an average of 27.2% per year. The number of OTA members increased each year except in 2009, with mean annual increase of 9.8%. The mean number of orthopaedic surgeons per NTDB center increased from 7.98 to 8.58, an average of 1.5% per year. The annual number of operative pelvis and acetabular fractures per NTDB center decreased from 27.1 in 2002 to 19.03 in 2012, following a declining trend of 2.0% per year.

Conclusion: In the US from 2002-2012 the number of OTS increased significantly, as did the mean number of orthopaedic surgeons per NTDB center. However, the number of annual operative pelvis and acetabular cases per reporting NTDB center declined. These trends suggest an overall net loss of annual orthopaedic trauma cases per OTS over this 10-year period. This supply and demand analysis suggests that the need for newly trained OTS may be diminishing, and that further monitoring and scrutiny of the orthopaedic trauma workforce is necessary.

Table 1: Supply and Demand data for practicing orthopaedic traumatologists

Supply	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Total U.S. Orthopaedic Surgeons[1]	-	-	23796	23905	24015	24739	25464	25463	25462	26617	27773
Percent change	-	-	-	0.5%	0.5%	3.0%	2.9%	0.0%	0.0%	4.5%	4.3%
Orthopaedists treating ortho trauma[2]	-	-	1904	1864	1825	1995	2164	3374	4583	4833	5083
Percent change	-	-	-	-2.1%	-2.1%	9.3%	8.5%	55.9%	35.8%	5.5%	5.2%
Total Orthopaedic Surgeons in NTDB† centers	-	-	-	-	-	3625	4159	5908	6090	6735	6903
Orthopaedic Surgeons per NTDB center	-	-	-	-	-	7.98	8.30	8.66	8.74	8.91	8.58
Percent change	-	-	-	-	-	-	4.0%	4.4%	0.9%	2.0%	-3.7%
Mean Orthopaedic Surgeons per NTDB centers											
Level 1	-	-	-	-	-	9.5	9.7	9.7	9.8	9.8	10.8
Level 2	-	-	-	-	-	8.8	9.5	9.5	9.9	9.9	9.8
Level ≥ 3	-	-	-	-	-	6.2	5.8	5.9	5.8	5.8	5.1
Unspecified	-	-	-	-	-	7.9	8.6	8.7	8.6	8.9	8.3
Trauma Fellowships Offered	-	-	-	-	-	-	81	81	82	81	78
Graduating trauma fellows	-	-	-	-	-	-	-	69	74	64	70
OTA Members‡	343	372	398	430	466	575	641	631	694	748	861
Percent Change	-	8.5%	7.0%	8.0%	8.4%	23.4%	11.5%	-1.6%	10.0%	13.0%	9.8%
Demand											
Total number of NTDB centers reporting	91	110	124	145	300	454	501	682	697	756	805
Level 1	-	-	-	-	101	104	110	124	119	119	120
Level 2	-	-	-	-	-	107	137	142	147	157	156
Level ≥ 3	-	-	-	-	-	52	61	90	91	92	93
Unspecified	-	-	-	-	-	192	193	326	340	388	436
Operative acetabulum fractures	1243	1368	1652	2137	3234	4673	5578	5904	6370	6639	7260
Operative pelvic fractures	1279	1354	1587	2415	3972	5268	6496	6749	7228	7204	8062
Operative P + A fractures*	2522	2722	3239	4552	7206	9941	12074	12653	13598	13843	15322
Percent change		7.93%	18.99%	40.54%	58.30%	37.95%	21.46%	4.80%	7.47%	1.80%	10.68%
Operative P + A cases per NTDB center	27.71	24.75	26.12	31.39	24.02	21.90	24.10	18.55	19.51	18.31	19.03
Percent change		-10.71%	5.56%	20.18%	-23.49%	-8.84%	10.1%	-23.0%	5.2%	-6.1%	3.9%

[1] From American Academy of Orthopaedic Surgeon (AAOS) Census Report

[2] AAOS Census data

† National Trauma Data Bank

‡ Orthopaedic Trauma Association: Includes active, associate, and clinical members

* Pelvic and acetabulum fractures

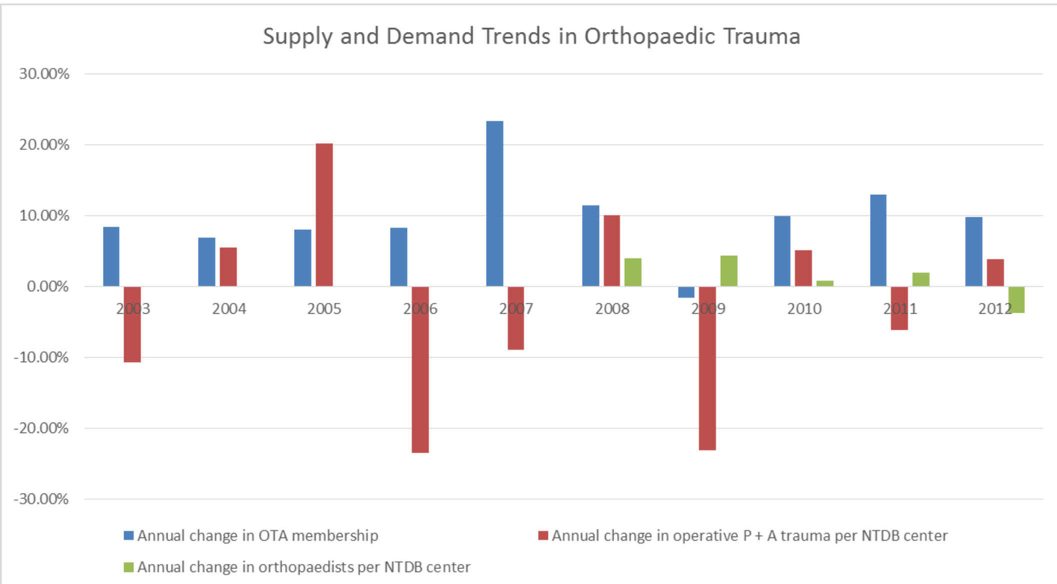

Figure 1: Annual rate of change is shown. Demand trends are estimated by change in operative case volume per NTDB center, supply trends are estimated by change in OTA membership as well as number of total orthopaedic surgeons per center

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Effect of a Dedicated Orthopaedic Advanced Practice Provider in a Level I Trauma Center: Analysis of Length of Stay and Cost

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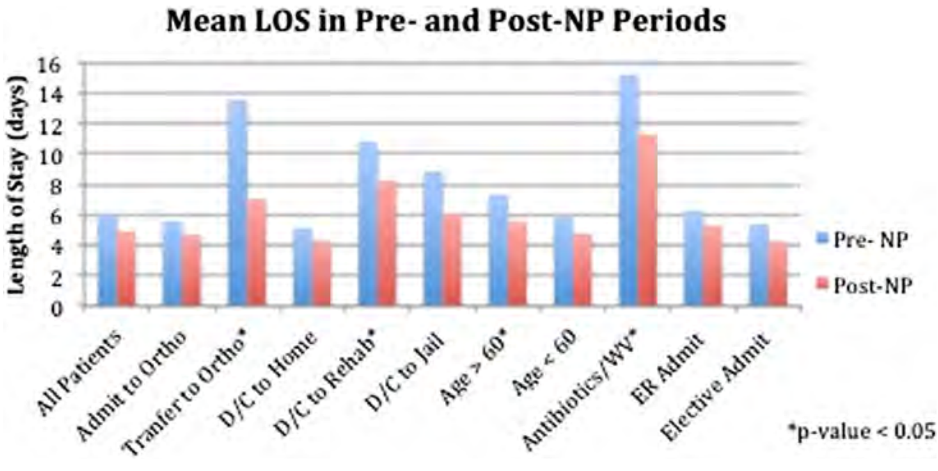
Purpose: The objective of this study is to analyze the effect of an orthopaedic trauma advanced practice provider on length of stay and cost in a Level I trauma center. The hypothesis of this study is that the addition of a single full-time nurse practitioner (NP) to the orthopaedic trauma team at a Level I trauma center would decrease overall length of stay (LOS) and hospital cost.

Methods: A retrospective chart review of all patients discharged from the orthopaedic surgery service 1 year prior to the addition of an NP (Pre-NP) and 1 year after the hiring of a NP (Post-NP) were reviewed. Chart review included age, gender, LOS, discharge destination, intravenous antibiotic use, wound-vac vacuum-assisted closure] therapy, admission location, and length of time to surgery. Statistical analysis was performed utilizing the Wilcoxon/Kruskal-Wallis test.

Results: The hiring of an NP yielded a statistically significant decrease in the LOS across the following patient subgroups: patients transferred from the trauma service (13.56 compared to 7.02 days; P <0.001), patients aged 60 years and older (7.34 compared to 5.04 days; P = 0.037), patients discharged to a rehab facility (10.84 compared to 8.31 days; P = 0.002), and patients discharged on antibiotics/wound-vac therapy (15.16 compared to 11.24 days; P = 0.017). Length of time to surgery was also decreased (1.26 compared to 1.01 days, P = 0.02). A cost analysis of the subgroup of patients transferred to orthopaedics from another service yielded a savings of $1,059,480 per year.



Conclusion: The addition of a dedicated orthopaedic trauma advanced practice provider at a county Level I trauma center resulted in a statistically significant decrease in LOS and

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thus reduced indirect costs to the hospital. Given the substantial indirect cost savings from a reduction in LOS provided from hiring a dedicated orthopaedic NP, it can be concluded that they provide the hospital with a positive net present value. This supports the hiring and maintenance of an NP to an orthopaedic team at an academic Level I trauma county hospital and should serve as a model on which to base future orthopaedic practices.

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Does Nutritional Intervention Improve Nutritional Outcomes in Orthopaedic Trauma Patients: A Randomized Prospective Study

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Purpose: Malnutrition is associated with poor clinical outcomes, including higher infection rates, impaired wound healing, depression of the immune response, longer length of stay (LOS), increased muscle loss, increased recovery time and increased mortality. A previous study conducted by our group displayed high prevalence rates of malnutrition in orthopaedic trauma patients that progressively worsened during the acute hospital stay, as diagnosed by laboratory markers. The primary aim of this study was to determine if aggressive nutritional consultation and protein supplementation could prevent malnutrition in the orthopaedic trauma patient population.

Methods: Orthopaedic trauma patients at a Level I regional trauma center were electronically randomized on admission to a control group versus a treatment group. The treatment group received nutritional counseling from a nutritionist on admission with protein supplementation at every meal. Furthermore, patients were seen by a study member on a daily basis and reminded of the importance of nutrition and counseled accordingly. Serum laboratory markers were obtained for both the control and treatment group on admission, hospital day 3, hospital day 7, and at 2 and 6 weeks post surgery. Nutritional markers included albumin, prealbumin, transferrin, CRP (C-reactive protein), and vitamin D. Nutritional status was determined using the validated Rainey MacDonald Nutritional Index (RMNI), with negative numbers representing malnutrition. The control group was treated based on the preference of the admitting team. Patient demographics, ISS, and surgical treatment were also recorded prospectively.

Results: 94 patients were enrolled, but 14 patients were excluded because either they were discharged before and/or appropriate labs were not drawn on hospital day 3 or they refused to continue to be in the study. Final analysis included 40 patients randomized to the control group and 40 patients in the treatment arm. As a result, 80 orthopaedic trauma patients with an average age of 47 years were included in the final analysis. No statistically significant difference was noted between the two groups in regards to: age, sex, ISS, and BMI (body mass index). Average nutritional marker values and statistics for the control arm and treatment arm are reported in the table. Based on the RMNI 38% of control patients were diagnosed as malnourished on admission, which increased to 60% by day 3 and remained elevated at 57% of patients being malnourished at hospital day 7. In the treatment arm on admission 20% of patients were malnourished based on RMNI; this increased to 93% on hospital day 3, and decreased to 57% by hospital day 7. CRP values significantly increased from admission to hospital day 3, but we did not see a significant increase from day 3 to day 7. Furthermore, no statistically significant difference was noted between the treatment arm and the control arm at the 2 and 6-week follow-up appointments in regards to the nutritional markers.

Conclusion: The prevalence of malnourishment, based on serum values of albumin and prealbumin and the RMNI, in the presence of acute orthopaedic injury, is substantial, and it continues to rise during the acute hospital stay. We were not able to prevent malnutrition based on laboratory markers with nutritional supplementation and counseling. This suggests that the nutritional markers we routinely utilize are not sensitive enough to measure a difference, or that the supplementation is ineffective. The next stage is to determine if counseling and protein supplementation leads to lower complication rates and better outcomes.

	Control	Treatment	p-value
Age	44	50	0.17
BMI	28	27	0.52
LOS	8	7	0.41
Admit CRP	60	47	0.23
Admit Prealbumin	18	20	0.17
Admit Albumin	3.6	3.7	0.07
Admit RMNI	0.51	0.75	0.21
Admit Vit. D	23	22	0.97
Day 3 CRP	122	108	0.39
Day 3 Prealbumin	11.1	11.9	0.72
Day 3 Albumin	3.2	3.3	0.64
Day 3 RMNI	-0.2	-0.12	0.09
Day 7 CRP	125	128	0.9
Day 7 Prealbumin	10.9	10.3	0.66
Day 7 Albumin	3.3	3.1	0.17
Day 7 RMNI	-0.15	-0.62	0.16

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Do Patients Know Their Postoperative Plan?
A Prospective Cohort Study of Orthopaedic Trauma Patients

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Background/Purpose: Postoperative physical therapy in the orthopaedic trauma population is thought to be important to help patients maximize functional recovery following an injury and surgery. Little previous work exists regarding patient comprehension of the postoperative plan in orthopaedic trauma patients. It was hypothesized that patient knowledge of postoperative physical therapy instructions following an orthopaedic injury would be low.

Methods: 194 patients were given a questionnaire testing their knowledge of their physical therapy plan following an acute orthopaedic injury and intervention. 212 patients were prospectively enrolled and identified over four separate convenience sample time periods between August 2013 and November 2014. Inclusion criteria consisted of patients age 16 or older who were admitted with an acute orthopaedic injury and returned for their first follow-up appointment during these time periods. Patients did not need to have surgery to be eligible for this study. Exclusion criteria consisted of patients with moderate to severe traumatic brain injury, spinal cord injury with neurologic deficit, and pathologic fractures. Four patients declined the study, five were excluded due to seeing a health care provider prior to filling out the questionnaire, and nine questionnaires were incompletely filled out, for a total of 194 completed questionnaires. The study patients had an average age of 46 years and included 65% Caucasians, 31% African-Americans, and 4% other races. 60% of participants were male and 56% had private insurance. The primary outcome measure was the percentage of patients who knew their postoperative physical therapy plan, based on correctly answering questions pertaining to weight-bearing status, range of motion, and bracing instructions. A secondary outcome was a composite knowledge score (0-1) that was created for 21 patients with intra-articular fractures of the knee or elbow who also had specific range of motion and bracing instructions.

Results: Despite the fact that 73% of patients were performing therapy exercises following hospital discharge, only 66% (95% confidence interval [CI]: 60-73) of patients correctly identified their postoperative weight-bearing status. Bivariate analysis revealed that non-white patients have 51% decreased odds of correctly identifying their weight-bearing status (P = 0.02) and patients with private insurance are 1.96 times as likely to correctly identify their weight-bearing status (P = 0.03). However, a multivariate model demonstrated that these associations are confounded as neither factor was significant when controlling for the other (P range 0.08 to 0.10). There were no significant differences in correctly identifying weight-bearing status with respect to age, gender, or discharge location. Only 12 out of 21 patients with intra-articular elbow and knee injuries were performing any range of motion exercises, and their mean knowledge score was only 0.7 (standard deviation [SD] 0.44-0.99). There were no significant differences in therapy comprehension with respect to age, gender, race, socioeconomic status, or discharge location.

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Conclusion: It was observed that orthopaedic trauma patient understanding of even the most basic postoperative physical therapy instructions is generally low. Intervention strategies to improve this deficit are likely justified. Surgeons should be aware that their postoperative plan may not be carried out correctly, even if the patient is undergoing physical therapy.

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Anterior-Inferior Plating Results in Fewer Secondary Interventions Compared to Superior Plating for Acute Displaced Midshaft Clavicle Fractures

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Purpose: We sought to determine if a difference in plate position for fixation of acute, displaced, midshaft clavicle fractures affects the rate of secondary intervention. Our null hypothesis was that there would be no difference.

Methods: After IRB approval, 266 patients treated surgically for an acutely displaced midshaft clavicle fracture between 2000-2012 were identified and reviewed retrospectively at a minimum of 24 months follow-up (F/U). Fractures were divided into two cohorts, according to plate position: anterior-inferior (AI) or superior (S). Exclusion criteria included age <16 years, incomplete data records, and loss to F/U. Group analysis included demographics (age, gender, BMI [body mass index]), fracture characteristics (mechanism of injury, open or closed), hand dominance, ipsilateral injuries, time between injury and surgery, time to radiographic union, length of F/U, and frequency of secondary procedures. Fisher exact test, t test and odds ratio were used for statistical analysis.

Results: Final analysis included 174 fractures/173 patients. 111 (64%) were in group AI, and 63 (36%) were in group S. No differences in demographics, fracture characteristics, time to surgery, time to union, or length of F/U existed between groups. Six patients/six fractures (5.2%) in Group AI underwent a secondary surgery (4 patients had the plate removed due to irritation, 1 developed an infected nonunion, and another fell, refracturing the clavicle) whereas 14 patients/14 fractures (21.8%) in group S required a secondary surgery (12 due to irritation from the plate, 1 developed a nonunion, and 1 presented with a fractured implant). An additional intervention secondary to superior plate placement was highly statistically significant ($P = 0.002$). Furthermore, because 80% of these subsequent interventions were a result of plate irritation with patient discomfort, the odds ratio for a second procedure was 5 times greater in those fractures treated with a superior plate.

Conclusion: This Level III therapeutic retrospective comparative study indicates that when all other variables are held equal, an anterior-inferior plate appears to lessen clinical irritation and results in significantly fewer secondary operations. Considering patient satisfaction and a reduced financial burden to the health care system, we recommend routine anterior-inferior plate application when open reduction and internal fixation of the clavicle is required.

Introducing the Surgical Therapeutic Index in Trauma Surgery: An Assessment Tool for the Benefits and Risks of Different Operative Fracture Treatment Strategies

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Background/Purpose: The concept of the Surgical Therapeutic Index (STI) has been described as an indicator of the benefits and risks of surgical treatment in other fields of surgery. The index is calculated by dividing the cure rate of an operative treatment by the complication rate and should be interpreted as expressing a certain level of safety; the higher a procedure's STI, the safer the procedure. The STI introduces a concept to critically evaluate the pros and cons of surgical fracture treatment in general. The optimal treatment of clavicle fractures has been a topic of debate for many years. Although many of these fractures may be treated successfully without surgery, displaced midshaft clavicle fractures (DMCFs) are often treated surgically. This study compares the indices for surgical plate fixation (PF) and intramedullary fixation (IMF) for the treatment of DMCF. The purpose of this study is to introduce the concept and philosophy of the STI into fracture treatment by using operative clavicle fracture fixation as an example.

Methods: In a randomized controlled fashion 120 patients were assigned to either PF (n = 58) or IMF (n = 62) with follow-up at 6 weeks, 3 months, 6 months, and 1 year after surgery. Cure was defined by a Disabilities of Arm, Shoulder and Hand (DASH) score of 8 or less. Complications were noted as present or not present for each follow up moment. In addition, a panel of experts provided weights to encountered complications in order to correct for the gravity of their consequences, resulting in unweighted and weighted STIs. After bias correction and using nonparametric bootstrapping, STIs were reported along with their 95% confidence intervals. The higher a procedure's STI, the higher the benefit/risk balance of that procedure.

Results: One year after surgery 50 patients (86%) in the PF group and 55 patients in the IMF group (89%) were considered cured (P = 0.67). Superficial infection occurred in 3 (5%) patients in the PF group and 4 patients (7%) suffered from a complication requiring major surgical revision. The IMF failed in 2 patients (3%) and the rate of implant-related soft-tissue irritation was 55%. The nonweighted STI after 6 weeks was significantly higher in the PF group. During further follow-up the differences leveled out and turned nonsignificant. When weighing the complications the indices decrease but are significantly in favor of the PF group at 6 weeks and 6 months after surgery. At 1 year postoperatively, differences are not significant.

Conclusion: The STI may be a reliable tool to assess the benefits and risks of operative fracture treatment. Further studies on clavicle and other fractures with consistent results of this new scoring system are needed, before conclusions can be generalized. When de-

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termining the indices of PF and IMF, a significant difference in favor of PF was observed during the early phase of recovery, which was prolonged when correcting for the gravity of consequences of complications by using severity weights. One year postoperatively, the STI for PF and IMF were similar.

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Effects of Injury and Social Factors on Functional Outcomes after Clavicle Fracture
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Purpose: Controversy exists regarding surgical indications for clavicle fractures. Practice patterns have shifted toward more operative care in recent years. The purpose of the study is to evaluate effects of patient demographic, injury, and social characteristics on functional outcomes of clavicle fractures.

Methods: 739 skeletally mature patients with clavicle fractures over a 14-year period were identified. At a mean of 56 months follow-up 214 patients completed the American Shoulder and Elbow Surgeons (ASES) survey. It is a 20-item questionnaire with scores up to 100 points, higher scores indicating better function. Effects of age, gender, fracture location, open fracture, associated injuries, tobacco or alcohol use, employment status, and type and timing of treatment were assessed.

Results: The mean ASES score for the entire group was 81.7. The study group was 73% male, with mean age 45.3 years (range, 16 to 89). Fractures were classified as medial (OTA 15-A, n = 15), midshaft (15-B, n = 157), and lateral (15-C, n = 39). 4% were open fractures. 77 (36.0%) were treated with plate fixation (ORIF [open reduction and internal fixation]), while 137 had nonoperative management; mean scores were 84.0 versus 78.5, respectively, P = 0.054. Further investigation revealed better ASES scores in surgical patients with lateral (88.8 vs 73.2, P = 0.04) and isolated (85.0 vs 69.6, P = 0.02) fractures compared to nonoperative patients. Those with clavicle fracture with concurrent head injury had better functional outcomes than isolated clavicle fractures when treated nonoperatively (84.6 vs 71.8, P = 0.033). Smokers (75.0 vs 82.9, P = 0.003) and unemployed (72.3 vs 84.6, P <0.001) had the lowest ASES scores. With the numbers available, ASES scores were not associated with age, gender, or open fracture, with the exception of better ASES scores in 30-40 year olds with operative treatment versus nonoperative (90.9 vs 65.7, P = 0.0008). Surgical timing was not related to outcome for patients treated <10 weeks versus >10 weeks, and <20 weeks versus >20 weeks after injury (both P >0.36).

Conclusion: Mean ASES scores showed good shoulder function in most patients. Indications for surgical care for clavicle fractures have been a topic of recent debate. This study provides insight for counseling patients on outcome expectations and highlights anatomical and social factors to be considered before determining a treatment plan. Additionally, initial nonoperative management for clavicle fractures may be a reasonable treatment plan with delay in surgical treatment showing no difference in ultimate outcomes.

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	ORIF (n=77)	Non-operative (n=137)	All patients (n=214)
Men	85.1	79.3	81.6
Women	79.7	76.7	77.5
Smokers*	76.3	74.4	75.0
Non-Smokers∞*	86.8	80.7	82.9
Employed∞ †	88.5	81.8	84.6
Unemployed †	69.5	73.3	72.3
Isolated ∞	85.0	69.6	80.3
Chest trauma	81.3	78.8	79.4
Multiple trauma	83.3	79.7	80.6
p<0.05: *all smokers v non-smokers; † all employed v unemployed; ∞ORIF v non-operative			

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Results and Outcomes after Midshaft Clavicle Fracture: Matched Pair Analysis of Operative Versus Nonoperative Management

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Purpose: Traditional conservative treatment of midshaft clavicle fractures has recently transitioned toward an operative approach in many patients. However, this is not a consensus practice in the orthopaedic community. Prior studies have not well defined those patients who benefit most from surgery, maintaining acceptable risk of complications and reasonable cost of care. This study evaluates clinical results and functional outcomes of closed, midshaft clavicle fractures for patients treated surgically matched with patients treated nonoperatively.

Methods: Closed, midshaft clavicle fractures in skeletally mature patients were identified from a Level I trauma center registry between 2002 and 2013. Eighty patients were treated primarily with open reduction and internal fixation with plating (ORIF), and 491 patients were treated nonoperatively. 71 matched pairs were generated based on age, gender,and fracture pattern (OTA 15B-1,2,3). Seven patients had inadequate radiographic follow-up after ORIF; although they had no known adverse events, they were excluded, leaving 64 pairs. Charts and radiographs were reviewed, and the American Shoulder and Elbow Surgeons (ASES) survey was administered. A poor outcome was defined as a treatment complication or ASES score <60.

Results: The study group consisted of 106 men and 22 women with mean age of 38.5 years (range, 16 to 71) and fracture patterns of 15B-1 (n = 76), 15B-2 (n = 44), and 15B-3 (n = 8). 38% of patients were tobacco smokers, with 22 in the operative group and 26 in the nonoperative group. Ten (15.6%) initial nonoperative patients underwent ORIF at a mean of 26 weeks (range, 7 to 48) due to persistent pain and motion at the fracture site, and 2 of these had elective implant removal after healing following ORIF. 14 of the 64 patients (21.9%) treated acutely with ORIF had 15 complications including: 1 deep infection, 2 nonunions, 1 malunion, 8 painful implants, and 3 implant failures, resulting in secondary procedures in 10 patients (15.6%). 35 patients with acute ORIF completed ASES surveys with mean score 81.7, while 64 initial nonoperative patients had mean ASES of 80.8. Seven patients (20.0%) after ORIF had ASES <60 (mean 40.5), while the initial nonoperative group had 9 patients (14.1%) with ASES <60 (mean 43.1, P = 0.84). Overall, the rate of poor outcomes was 20 of 64 in the operative group (31.3%) and 18 of64 (28.1%) in the nonoperative group. Unemployment (P = 0.023) was associated with poor outcome, irrespective of type of treatment, while smoking (P = 0.13) and alcohol abuse (P = 0.29) were not significant with the numbers available.

Conclusion: Patient selection is an important factor in achieving good surgical outcomes. For patients matched in age, gender, and fracture pattern, initial surgical versus nonsurgical treatment resulted in similar total complication rates and no difference in functional outcomes. Social factors may prove to be greater predictors of outcomes. We support consideration of initial nonoperative management in closed midshaft clavicle fractures in patients with social risk factors for poor outcome.

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Scapular Dyskinesis Following Displaced Fractures of the Middle Clavicle

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Purpose: This study was conducted to evaluate the rate of scapular dyskinesis and resulting patient outcomes following treatment of displaced, midshaft clavicle fractures.

Methods: Skeletally mature patients who sustained isolated, displaced midshaft clavicle fractures treated with or without surgery over a 16-month period were recruited. The minimum follow-up at study examination was 12 months. Patients were excluded with age less than 21 or over 80 years of age at the time of injury, and if they had concurrent traumatic injuries, prior fractures on the injured side, neurological injury (peripheral or spinal cord), frozen shoulder, shoulder replacement, and patients who were nonambulatory or not living independently. Based on these criteria, 32 patients were eligible for enrollment. Patient outcomes were documented using the SICK (Scapular malposition, Inferior medial border prominence, Coracoid pain and malposition, and dysKinesis of scapular movement) Scapula Rating Scale, Simple Shoulder Test (SST), three visual analog scale (VAS) pain scales, shoulder range of motion (ROM), and strength measurements. Scapular dyskinesis was defined as winging of the scapula at rest or with active abduction and at least a 1.5 cm or 5° difference in the resting position of the affected scapula compared to the unaffected. 24 patients (75%; 24 of 32) were successfully recruited.

Results: Average study participant age was 46 ± 17 years with a mean follow-up at time of study evaluation of 1.7 ± 1 years. Twelve (50%) underwent surgical fixation. Scapular dyskinesis was present in 37.5% (n = 9) of patients, and only 1 (11%; n = 1 of 9) of these patients had SICK scapula syndrome. The patients with scapular dyskinesis were similar regarding age, body mass index, psychiatric comorbidity, smoking status, initial fracture displacement, and length of time from injury or surgery to study examination compared to patients without dyskinesis. The patients with scapular dyskinesis had worse SICK scapula scores (5.8 ± 2.2 vs 3.1 ± 2.4; P = 0.01), worse SST scores (10.5 ± 1.6 vs 11.7 ± 0.8; P = 0.029), and worse average VAS pain scores in the week prior to examination (2.7 ± 2.5 vs 0.2 ± 0.4; P <0.001) compared to patients without dyskinesis. ROM and abduction strength measures did not differ between groups. Only 1 patient treated with surgery (8%; n = 1 of 12) developed scapular dyskinesis, compared to 8 of 12 patients (67%) treated nonoperatively (P = 0.009).

Conclusion: Scapular dyskinesis is common after displaced, midshaft clavicle fractures and these patients experience more pain and have worse functional outcomes compared to patients who do not develop scapular dyskinesis. Surgical treatment of this injury may reduce a patient's risk for developing scapular dyskinesis and improve short-term outcomes.

Proximal Humerus Fracture Fixation with Locking Plate: Screws with a Length of 45 mm or Longer Are Related to Increased Risk of Cutout

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Purpose: The arrival of locking plate systems for the fixation of proximal humerus fractures (PHFs) has changed the treatment for this condition, but also exposed patients and physicians to new complications. One of the complications most often reported in the literature is intra-articular screw perforation (cutout). Factors related to screw cutout are not known. Since there are no clear guidelines regarding the maximal screw length, our study focuses on assessing the screw length associated with postoperative complications. Our hypothesis is that patients sustaining a PHF treated with screws P >45 mm are subjected to more cutout and reoperations.

Methods: We retrospectively analyzed the radiographic and demographic data from cases of PHF treated with the Synthes Philos locking plate. All patients were operated at our institution between 2007 and 2013 with a mean follow-up of 12 months. Charts were reviewed for postoperative complications. A validation study was conducted in which a synthetic humerus fixated with screws of predetermined lengths underwent radiographs at variable angles. This allowed us to identify screws >45 mm on follow-up images with a level of confidence of 99%. Measurements were made with the SliceOMatic software and adjusted using the size of the plate to calculate a scaling ratio. We also measured the mediolateral head impaction, neck angulation, and height change between the first and last follow-up.

Results: We identified 171 cases with a mean age of 62 years (range, 17 to 94) and 116 females. A total of 80 complications were reported in 58 patients. 34 patients had cutout (20%) and of these, 14 (41%) were reoperated due to this complication. 81 patients (46%) had at least one screw >45 mm. Patients with screws >45 mm had a 2.5 risk of cutout (P = 0.016) and 37% increased risk of reoperation. The presence of cutout was significantly associated with more complex fracture (Neer I-II = 17% vs Neer III-IV = 33%, P = 0.017), initial varus deformity (34% vs 15%, P = 0.05), osteonecrosis (55% vs 21%, P = 0.003) and longer OR (operating room) time (P = 0.019). Age, gender, diabetes and smoking did not correlate with cutout.

Conclusion: Incidence of screw cutout is associated with the length of screws and the fracture characteristics rather than patient's demographics or past-medical history. Our study points out the dramatic aspect of screw cutout and the subsequent risk of reoperation. It highlights the importance of avoiding the use of locking screws >45 mm when treating PHF.

See pages 47 - 108 for financial disclosure information.

The Impact of Residual Angulation on Patient-Reported Functional Outcome Scores after Nonoperative Treatment for Humeral Shaft Fractures

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Purpose: Data looking at the magnitude of residual angulation in the healed humeral diaphysis and its relationship to patient reported outcomes are lacking. The purpose of this study was to identify if correlation exists between residual angular deformity after nonoperative treatment for humeral diaphyseal fractures and patient-reported outcome measures, including patient satisfaction.

Methods: Patients treated from 2004-2011 for humeral shaft fractures were retrospectively identified for 3 surgeons at a single institution. All skeletally mature patients at least 1 year post-injury at the time of study participation were included in the study. Patients were excluded if they were treated surgically, were deceased, did not have available contact information, diagnosed with dementia, had subsequent but unrelated trauma or surgery to the injured extremity, and non-English speaking. 42 patients met criteria and were recruited by telephone to obtain the following outcome scores: Disabilities of the Arm, Shoulder, and Hand (DASH), the Simple Shoulder Test (SST), and general health questionnaire Short Form-12 physical component summary (SF-12 PCS) and mental component summary (SF-12 MCS). The patient chart was reviewed to analyze most recent radiographs to obtain residual diaphyseal angulation in the sagittal and coronal planes. Pearson correlation coefficients and Student t tests were calculated with IBM SPSS v19, with significance set at $P < 0.05$. All values are average ± standard deviation.

Results: 32 patients were successfully recruited with an average age 45 ± 22 years, and average time from injury to study follow-up being 47 ± 29 months. The average outcome scores were DASH 12 ± 16, SST 10 ± 2.7, SF-12 PCS 50 ± 7.9, and SF-12 MCS 54 ± 8.8. Healed angular deformity in the sagittal plane measured on average 8° ± 5.7° (range, 0-18), and 15° ± 7.9° (range, 2-27) in the coronal plane. There was no significant correlation between residual sagittal plane angular deformity and outcome scores (DASH score $r = -0.14$, $P = 0.47$; SST $r = 0.22$, $P = 0.25$). There was no significant correlation between residual coronal plane angular deformity and outcome scores (DASH score $r = -0.17$, $P = 0.38$; SST $r = 0.28$, $P = 0.14$). All patients had less than 20° of residual sagittal plane deformity. Seven patients (22%) had residual coronal plane deformity of at least 20°. These 7 patients had similar DASH scores (13.2 ± 18.7 vs 11.7 ± 16.1; $P = 0.83$), SST scores (10.3 ± 2 vs 10.0 ± 2.9; $P = 0.81$), and overall satisfaction with their treatment ($P = 0.08$) and cosmesis ($P = 0.44$) compared to the rest of the cohort. Higher SF-12 PCS scores correlated with better DASH ($r = -0.49$, $P = 0.007$) and SST scores ($r = 0.52$, $P = 0.004$). Similarly, higher SF-12 MCS scores also correlated with better DASH ($r = -0.41$, $P = 0.03$) and SST scores ($r = 0.47$, $P = 0.01$). There was no significant correlation between outcome and age for either measure ($P = 0.41$ for DASH and SST).

Conclusion: Residual angular deformity ranging from 0-18° in the sagittal plane and from 2-27° in the coronal plane after nonoperative treatment for humeral shaft fractures had no

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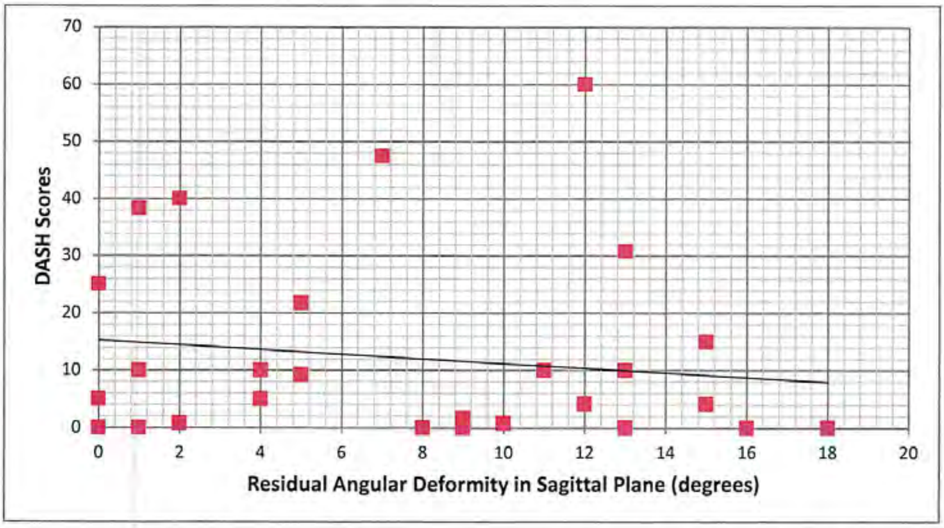
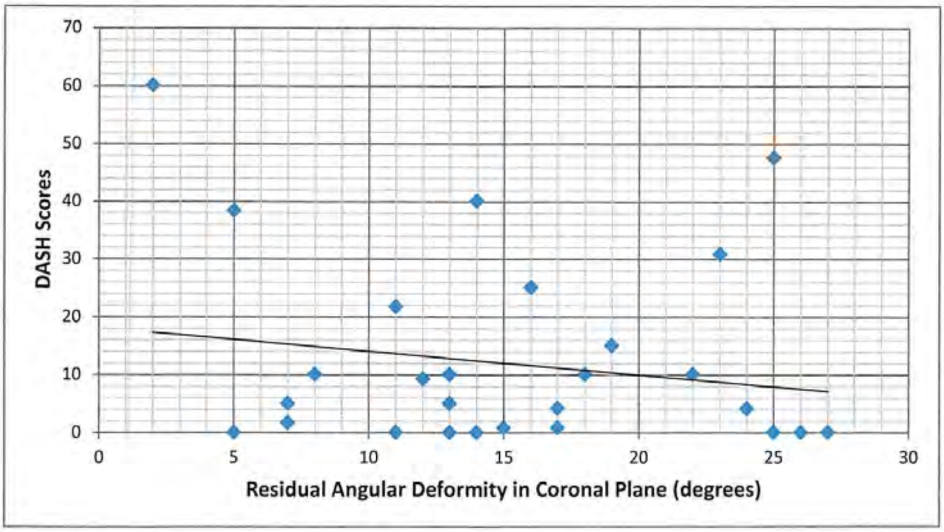
correlation with patient reported DASH scores, SST scores, or patient satisfaction. Instead, overall physical and mental health status as measured by the SF-12 significantly correlated with patient-reported outcomes.

Figure 1. Scatter plots with best fit line for angular deformity in the sagittal and coronal planes after humeral shaft fractures and resulting DASH scores.

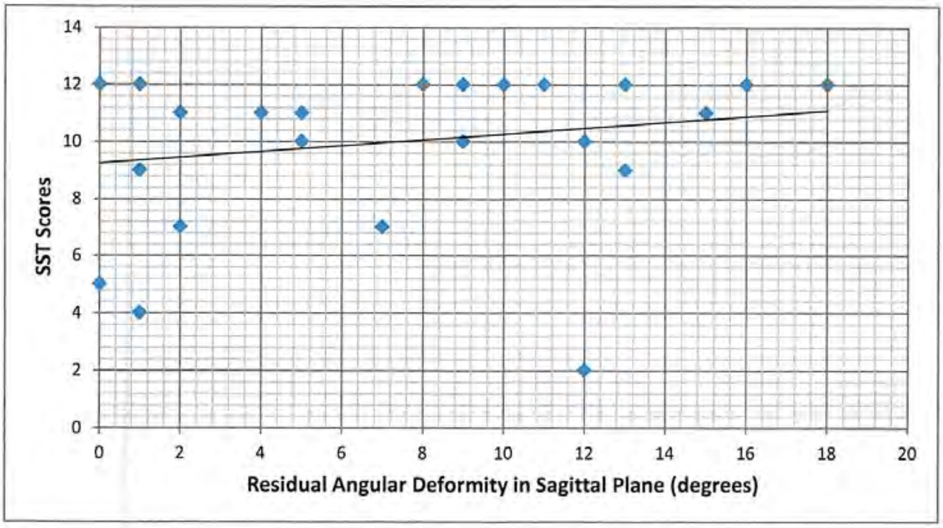


A. There was no correlation between residual angular deformity of the humeral shaft in the sagittal plane and resulting DASH scores (r=-0.14; P=0.47).

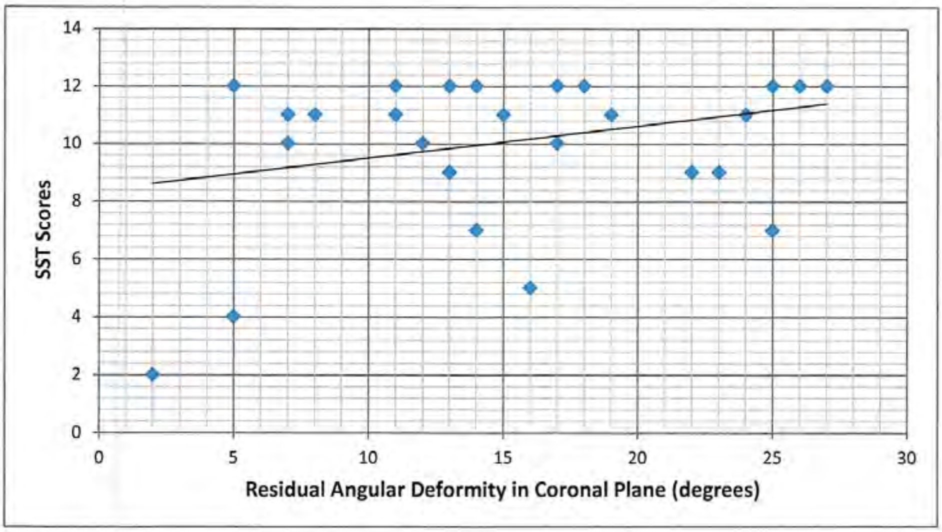


B. There was no correlation between residual angular deformity of the humeral shaft in the coronal plane and resulting DASH scores (r=-0.17; P=0.38).

Figure 2. Scatter plots with best fit line for angular deformity in the sagittal and coronal planes after humeral shaft fractures and resulting Simple Shoulder Test (SST) scores.



A. There was no correlation between residual angular deformity of the humeral shaft in the sagittal plane and resulting Simple Shoulder Test (SST) scores (r=0.22; P=0.25).



B. There was no correlation between residual angular deformity of the humeral shaft in the coronal plane and resulting Simple Shoulder Test (SST) scores (r=0.28; P=0.14).

Scoring Cortical Healing of Humeral Shaft Fractures Improves Interobserver Reliability

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Purpose: Determining when a fracture of a long bone is united can be difficult. Scoring systems such as the radiographic union score for tibial fractures (RUST) and the radiographic union score for hip (RUSH) have improved interobserver reliability in determining the degree of healing of long bone fractures. The purpose of this study is to determine if a modified RUST score applied to nonoperatively treated humeral shaft fractures can increase interobserver reliability in determining degree of fracture healing.

Methods: Three fellowship-trained orthopaedic traumatologists and one fellowship-trained musculoskeletal radiologist scored 50 cases (100 radiographs) of humeral shaft fractures in various stages of healing using a modified RUST scoring system called the Radiologic Humerus Union Measurement (RHUM). All observers were blinded to time from injury. After a 4-week washout period, observers again scored the same cases. Cases were presented in random order with each attempt. Observers classified each fracture as either healed or not healed based on the combination of the two radiographs for the case. Inter- and intraobserver reliability of the RHUM scoring system applied to humeral shaft fractures were determined using an intraclass correlation coefficient (ICC). Interobserver reliability of determining if a fracture is healed was calculated using Cohen's kappa (κ) statistics.

Results: ICC showed almost perfect interobserver reliability (ICC 0.838, ICC 95% confidence interval [CI] 0.765 to 0.896) and intraobserver reliability (ICC range 0.822 to 0.948) with applying the RHUM scoring system to humeral shaft fractures. Cohen's kappa showed substantial agreement between observers in determining fracture healing (κ = 0.647).

Conclusion: The RHUM score applied to humeral shaft fractures showed greater interobserver reliability than overall perception of healing. This is the first time that a cortical scoring system has been shown to have excellent interobserver reliability in a long bone fracture that was not treated operatively. The RUST score applied to the humerus may allow for orthopaedic surgeons to predict healing of humeral shaft fractures, as has been shown for the RUST score in the tibia.

See pages 47 - 108 for financial disclosure information.

Optional Follow-up Visits for Common, Low-Risk Arm Fractures

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Purpose: Many common arm fractures have an excellent prognosis with little more than symptomatic treatment, and an additional follow-up visit after diagnosis might not always be necessary. This study tested the primary null hypothesis that there is no difference in disability (QuickDASH [an abbreviated version of the Disabilities of the Arm, Shoulder and Hand) 2 to 6 months after injury between patients with and without an additional follow-up visit. Secondarily we assessed (1) differences in pain, satisfaction, and return to work at 2 to 6 months after injury; (2) differences between patients choosing an optional or scheduled follow-up; and (3) factors associated with returning after initially choosing not to schedule a follow-up visit.

Methods: We prospectively enrolled 120 patients with well-aligned single metacarpal fractures (n = 63), non- or minimally displaced distal radius fractures (n = 39,) and isolated non- or minimally displaced radial head fractures (n = 18). 56 (47%) subjects chose to schedule an additional appointment for evaluation of their fracture and 64 (53%) did not. At enrollment we recorded patient demographics, depression (Patient Health Questionnaire-2), Pain Self-Efficacy Questionnaire, disability (QuickDASH), a 0-10 ordinal rating of pain intensity, and satisfaction rated on an 11-point ordinal scale. 82 subjects (68%) were available when contacted by phone or email 2-6 months after injury at which time we measured disability, numerical rating scale for pain and satisfaction, and employment. 11 of 64 subjects (17%) who chose an optional follow-up returned for a follow-up visit. 9 of 56 subjects (16%) who scheduled a follow-up visit did not return. There were no adverse events in either group.

Results: Multivariable analysis accounting for difference in baseline characteristics showed no difference in QuickDASH between 2 and 6 months after fracture between patients with and without an additional visit (optional follow-up: ß -0.53, 95% confidence interval [CI] -7.4 to 6.4, standard error [SE] = 3.5, P = 0.88). There were no differences in pain, satisfaction, or return to work. On multivariable logistic regression analysis, no variables were independently associated with choosing optional or scheduled follow-up. The only factor independently associated with returning after not initially scheduling a follow-up visit was a higher QuickDASH score (odds ratio [OR] 1.05, 95% CI 1.0 to 1.1, SE 0.024, P = 0.029). In other words, on average patients returning after initially choosing not to had 1.05 point greater disability.

Conclusion: In an urban academic hand surgery office, more patients prefer optional follow-up for simple upper extremity fractures with a good prognosis. There were no adverse events and there were equal outcomes and satisfaction among patients who did and did not return. Hand surgeons can safely consider offering patients with low-risk hand fractures an optional of a scheduled second visit, avoiding unnecessary waiting, travel, inconvenience, time, tests, and costs.

Impact of Olecranon Fracture Malunion: Study on the Importance of PUDA (Proximal Ulna Dorsal Angulation)

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Background/Purpose: Olecranon fractures are associated with permanent and significant decrease of range of motion (ROM) in 30% of the patients. The PUDA is the physiologic dorsal bow of the proximal ulna (mean 6°, range 0-140) that is symmetrical from the right and left elbow. A previous biomechanical study showed impaired elbow alignement with a PUDA malunion of 5° or more. The goal of this study is to evaluate the impact of a PUDA malunion on elbow ROM and function 1 year or more after olecranon open reduction and internal fixation (ORIF).

Methods: The radiological and surgical database of three trauma centers were reviewed and all adults who underwent ORIF for olecranon fracture were invited to join the study. Bilateral elbow radiographs, radiographic ROM measurement, PUDA malunion, demographic data, and quality of life questionnaires were recorded (PREE [Patient-Rated Elbow Evaluation, Q-DASH [an abbreviated version of the Disabilities of the Arm, Shoulder and Hand], SF [Short Form]-12, VAS [visual analog scale}). ROM and PUDA were measured using Slice-o-Matic software and following a validated method. In this case control study, patients were classified according to the difference of the PUDA between the fracture side and the normal side. Patients were categorized as “PUDA malunion” when the PUDA difference was 5° or more. Our hypothesis was that 50% of patients would present a PUDA malunion and subsequently affect their ROM and function.

Results: 49 patients entered the study; 28 of them were females. Mean age was 54 years (range, 21-76). The mean follow-up was 3 years and 9 months (range, 1-7 years). ORIF method was tension band in 23 cases and plate-screws in 26. There was no difference in terms of outcome, quality of reduction, or ROM between those two methods. The mean ROM on the fracture side was 122° compared to 135° on normal side (P <0.001). The mean PUDA on the fracture side was different from the normal side (3.0 vs 4.20, P = 0.013). Twelve patients (25%) presented PUDA malunion. Those patients had decreased elbow flexion of 8° (P = 0.05) as opposed to the control group. Decrease elbow flexion was the strongest predictor of functional outcome and showed moderate correlation with Q-DASH (r = -0.3, P = 0.025), MEPS (Mayo Elbow Performance Score (r = 0.4, p=0.007) and PREE (r = -0.3, P = 0.019).

Conclusion: PUDA malunion was present in 25% of patients and was associated with decreased elbow flexion. Flexion loss has a greater impact than extension on functional outcome. Tension band and plate fixation can maintain good reduction in terms of PUDA and are not influencing outcome.

See pages 47 - 108 for financial disclosure information.

Surgical Treatment of Chronic Elbow Dislocation Allowing Early Range of Motion: Operative Technique and Early Clinical Results

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Background/Purpose: Management for a chronic elbow dislocation is a difficult problem. Historically, results have been suboptimal due to elbow stiffness, recurrent instability, and dysfunction of the triceps extensor complex. Postoperative complications have led some surgeons to recommend against surgical procedures for older patients and patients who are greater than 3 months out from initial injury. We report on an operative technique we have developed that allows early range of motion with little risk of dislocation. Our hypothesis is that our surgical technique and postoperative protocol allows for good patient outcome regardless of injury duration.

PAPER ABSTRACTS

Methods: We performed a retrospective review of clinical and radiographic records of patients who had undergone surgical treatment for chronic elbow dislocation. We excluded patients with associated fracture. Physical examination, the Mayo Elbow Performance Index (MEPI), and radiographs were obtained on all patients. Operative technique involved both medial and lateral approaches to the elbow while sparing the triceps. The ulnar nerve was transposed anteriorly. All soft tissues are dissected off of the distal humerus. The distal humerus was delivered out of either incision depending on ease of delivery. The olecranon fossa and coronoid fossa were cleared of soft tissue and the elbow was reduced after transposition of the ulnar nerve anteriorly. While there was no attempt to individually reconstruct the elbow ligaments, the soft-tissue envelope was repaired around the elbow as sleeves. Physical therapy for range of motion (0-90°) was initiated two days after surgery. Prophylactic indomethacin was given immediately to prevent heterotopic ossification.

Results: 25 patients (20 males) with a mean age of 25 years (range, 7-56 years) met inclusion criteria for this study. The mean patient follow-up was 5 months (range, 1-15 months). Duration of dislocation averaged 6 months (range, 1-34 months, standard deviation [SD] 7 months). Mean preoperative range of motion (ROM) was 7° (range, 0-30°). Mean ROM at final follow-up was 94° (range, 55-125°, SD 24°). The mean postoperative MEPI was 88 (range, 80-100). All patients had improvement in elbow motion. There were no infections or recurrent dislocations. There was one patient who developed transient ulnar nerve palsy postoperatively.

Conclusion: This is one of the largest case series of surgically treated patients with chronic elbow dislocation. All patients had improved elbow function and there were few complications. Open reduction of chronic elbow dislocation can be accomplished while permitting early motion and with little risk of dislocation. Long-term follow-up will be required to determine if these early clinical results continue.

Posttraumatic Elbow Arthrofibrosis Incidence and Risk Factors: A Retrospective Review

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Purpose: Loss of elbow range of motion can significantly decrease patient quality of life and have marked affect on outcomes. Posttraumatic arthrofibrosis is a common cause of decreased elbow range of motion (ROM) in adults. A loss of 50% of elbow motion has been found to compromise 80% of upper extremity function. Although arthrofibrosis has been extensively studied in the lower extremity, sparse data exist concerning this problem in the upper extremity. The aim of this study is to examine the incidence and risk factors of posttraumatic elbow arthrofibrosis.

Methods: We conducted a retrospective chart review of intra-articular elbow fracture patients seen at our trauma Level I hospital from March 2004 to January 2014. Demographic information, final range of motion, duration of immobilization, fracture pattern, injury mechanism, additional surgery, postoperative deep infection, and medical comorbidity data were recorded. Patients were included in the study if they had a minimum of 3 months follow-up or return to functional arc ROM (defined as a flexion/extension arc of at least 100° in the absence of an elbow flexion contracture greater than 45°) prior to 3 months. Pearson chi-squared and Student t test were used to evaluate categorical and continuous variables, respectively. A logistic multivariate regression model was used to predict arthrofibrosis risk factors. Statistical significance was set at a P value of <0.05.

Results: 470 consecutive patients with intra-articular elbow fractures were identified. 390 patients (83%) were included in the study. 80 patients were excluded from the study because of inadequate follow-up or ROM documentation. 302 patients had documented return to a functional arc range of motion; 88 (23%) patients developed elbow arthrofibrosis. There were no statistically significant differences between the two groups in terms of age, gender, or medical comorbidities. Duration of immobilization, fracture pattern, and energy were all statistically significant predictors of arthrofibrosis. Average time of immobilization was 19 days in patients who developed arthrofibrosis as compared to 13 days of immobilization in patients who recovered a functional arc ROM (P <0.001). High-energy mechanism increased the risk of arthrofibrosis with 44 of 126 (35%) high-energy injuries developing arthrofibrosis as compared to 44 of 264 (17%) low-energy injuries (P <0.001). 7 of 16 (44%) patients with deep postoperative infection developed arthrofibrosis as compared to 81 of 374 (22%) noninfected patients (P = 0.038). Elbow fracture dislocations and distal humerus fractures demonstrated statistically significant increased rates of arthrofibrosis with 24 of 67 (36%) patients with elbow fracture dislocations and 27 of 99 (27%) of distal humerus fractures developing arthrofibrosis (P = 0.005, P = 0.027, respectively). Only 22 of 136 (16%) olecranon and 15 of 88 (17%) radial head fractures went on to develop arthrofibrosis (P = 0.194, P = 0.159, respectively). Average follow-up was noted to be 242 days.

Conclusion: The functional sequelae of posttraumatic elbow arthrofibrosis can be extraordinarily disabling. Understanding the rate at which this process affects patients and the

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predictive risk factors associated with its development is critical. To our knowledge, this study is the first to demonstrate that 23% of patients with intra-articular elbow fractures go on to develop posttraumatic elbow arthrofibrosis. Additionally, duration of immobilization, fracture pattern, and energy were predictive risk factors for the development of elbow arthrofibrosis. Although fracture pattern and injury are nonmodifiable predictors of arthrofibrosis, duration of immobilization proves to be an important modifiable predictor of arthrofibrosis.

Table 1. Results of Multivariate Logistic Regression Evaluating Predictors of Elbow Arthrofibrosis

Variable	*p-value*
Age	0.94
Alcohol	0.480
Days of Immobilization	<.001
Deep Infection	0.038
Diabetes	0.095
Distal Humerus Fracture	0.027
Elbow Fracture-Dislocation	0.005
Olecranon Fracture	0.159
Radial Head Fracture	0.194
Sex	0.963
Tobacco	0.856

Early Mobilization Versus Plaster Immobilization of Simple Elbow Dislocations: A Cost Analysis of the FuncSiE Multicenter Randomized Clinical Trial

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PAPER ABSTRACTS

Background/Purpose: To our best knowledge no studies have reported the burden of simple elbow dislocations on health care costs. It is unknown whether or not early mobilization after reduction might play a role in reducing these costs. The primary aim of this study was to assess and compare the total costs (direct health care costs and indirect costs due to loss of production) after early mobilization versus plaster immobilization in patients with a simple elbow dislocation. The secondary aim was to evaluate cost-effectiveness. It was hypothesized that early mobilization would not lead to higher direct and indirect costs than plaster immobilization.

Methods: This cost-effectiveness study used data of a multicenter randomized clinical trial comparing early functional treatment with plaster immobilization in patients after simple elbow dislocations (blinded trial). From August 25, 2009 until September 18, 2012, patients aged 18 years or older with a simple elbow dislocation from 3 academic and 19 nonacademic hospitals were recruited and randomized to early mobilization (immediate motion exercises; n = 48) or 3 weeks plaster immobilization (n = 52). Follow-up was 1 year. Primary outcome were the total costs at 1 year. Analysis was by intention to treat.

Results: 100 patients were included; one patient was lost to follow-up after 6 months. QuickDASH (an abbreviated version of the Disabilities of the Arm, Shoulder and Hand) was lower in the early mobilization group at 6 weeks, but not at later time points. There were no significant differences in health-related quality of life measured with the EuroQol EQ-5D, Short Form (SF)-36 PCS (physical component summary), and SF-36 MCS (mental component summary) between the two groups throughout the 1-year follow-up. Mean total costs per patient were €3624 in the early mobilization group versus €7072 in the plaster group (P = 0.094). Shorter work absenteeism in the early mobilization group (10 vs 18 days; P = 0.027) did not lead to significantly lower costs for productivity loss (€1719 in the early mobilization group vs €4589; P = 0.120).

Conclusion: From a clinical as well as a socioeconomic point of view, early mobilization should be the treatment of choice for a simple elbow dislocation. Plaster immobilization has inferior results at almost double costs, and should therefore be abandoned.

See pages 47 - 108 for financial disclosure information.

Dorsal Tangential View: A Useful Tool for Assessment of Dorsal Screw Penetration in Distal Radius Fracture Fixation?

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Background/Purpose: The dorsal tangential view (DTV) provides unique perspective to the topography of the dorsal cortex of the distal radius. It is taken with the wrist hyperflexed and the fluoroscopic beam aimed tangential to the dorsal surface of the radius. Although studies have reported the utility of this view as an adjunct to traditional fluoroscopy, no studies have evaluated its value in detecting dorsal screw penetration compared to CT scan. This study was performed to assess the DTV utility in detecting intraoperative dorsal screw penetration in distal radius fractures treated with volar plating, compared to CT scan.

Methods: We prospectively collected data on 30 consecutive distal radius fractures in 25 patients treated with volar locked plating. Intraoperative AP, lateral, and 20° tilted lateral and dorsal tangential views were obtained via fluoroscopy in all wrists. A postoperative CT scan was obtained prior to patient discharge to assess fracture and implant position. We recorded the number and location of screws with dorsal penetration identified by each radiographic view and CT scan. Metaphyseal dorsal screw penetration was recorded as >1 mm of penetration. Statistical analyses were performed to assess the utility of the DTV in identifying dorsal screw penetration, compared to CT scan.

Results: 175 metaphyseal screws were assessed. Eight patients out of twenty-five (32.0%) had prominent screws evident on the DTV but not seen on standard fluoroscopic analysis; seven of eight patients underwent screw exchange for a shorter screw. The radial styloid screw was the most common position exchanged. CT scan identified five additional screws with >1 mm dorsal penetration not identified by the DTV. All but one of these were in the second dorsal wrist compartment. The DTV was 66.7% sensitive with a negative predictive value of 97.0% for screws >1 mm of dorsal cortex penetration. The DTV was least sensitive in detecting dorsal penetration in the second dorsal compartment, failing to detect four screws in this compartment. The DTV failed to detect one prominent screw placed in the fourth dorsal compartment as well.

Conclusion: The dorsal tangential view is an economic alternative to CT scan to ensure proper screw depth, reducing the risk of extensor tendon irritation and possible tendon rupture in most wrist compartments. We advocate the routine use of this view to help prevent prominent dorsal screws with volar locked plating of the distal radius and suggest caution when using this view to verify acceptable placement of screws in proximity to the second dorsal compartment.

Timing of Treatment of Open Distal Radial Fractures in Adults

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Purpose: Controversy exists regarding the ideal timing of the treatment of open distal radial fracture (DRFs). Two options exist after initial irrigation and debridement: (1) immediate, definitive open reduction and internal fixation (ORIF) or (2) external fixation and delayed ORIF. We hypothesized that there would be increased infection rate in group 1.

Methods: We retrospectively reviewed 7 years (2005-2012) of our prospectively collected database to identify all patients 16-65 years old with open DRFs and >3 months of clinical follow-up consistent for CDC (Centers for Disease Control and Prevention) definition of acute surgical site infection. The study group included 92 patients (94 fractures) with an average follow-up of 30 months. All patients were classified as either (1) immediate ORIF (n = 64) or (2) delayed ORIF (n = 32). The decision treatment was made based on the preference of the attending surgeon on the on-call night. Demographics, injury characteristics, and associated injuries were similar in the two study groups (P >0.20). The primary outcome measure was return to the operating room for surgical site infection. The secondary outcome was unplanned reoperation.

Results: In contrast to our hypothesis, 23% of patients (n = 7) in the staged group had infections requiring surgery compared to only 11% (n = 7) in the immediate ORIF group (P = 0.13, Pearson chi-square two-tailed). There was a trend toward increased reoperation rate in the staged group (50%) versus the unstaged group (33%) (P = 0.11). Both groups had similar functional outcomes as judged by range of motion and QuickDASH (an abbreviated version of the Disabilities of the Arm, Shoulder and Hand).

Conclusion: This relatively large case series on this topic demonstrates that fractures treated with immediate ORIF yield infection and reoperation rates similar to those fractures that are treated in a staged fashion. As a result, we conclude that initial debridement and internal fixation in these high-energy fractures is safe and has the potential benefit of sparing the patients an additional procedure that would otherwise be needed if treated in a staged fashion.

See pages 47 - 108 for financial disclosure information.

Posterior Facet Settling and Changes in Bohler's Angle in Operatively and Nonoperatively Treated Calcaneus Fractures: Implications for Management

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Background/Purpose: Bohler's angle (BA) is the most commonly used parameter to measure the amount of depression of the posterior facet after calcaneus fractures and has been shown to be prognostic for outcomes. Some patients exhibit a decrease in BA during the recovery period following either operative or nonoperative treatment. This settling may be multifactorial in nature and may lead to worse functional outcomes. Critical examination of patient demographic and surgeon-specific factors that may contribute to settling has not been studied in the literature. The purpose of this study was to identify the predictive factors that may lead to settling so that surgeons can limit this secondary loss of alignment and possibly improve calcaneus fracture outcomes.

Methods: 234 patients with intra-articular calcaneus fractures were analyzed. All patients had preoperative plain radiographs, at least 5 months of orthopaedic follow-up, and CT scanning performed. BA was measured on injury radiographs for all patients. For operatively treated patients, BA was measured on immediate postoperative radiographs and compared to the last available radiograph. For nonoperatively treated patients, BA was measured on the last available radiograph. All patients were fully weight-bearing at the time of final follow-up. Demographic data including age, gender, energy of injury mechanism, tobacco use, diabetes, osteoporosis, rheumatoid arthritis, and substance/alcohol abuse were retrospectively collected. Fractures were classified utilizing the Essex-Lopresti and Sanders classifications. Time to full weight bearing was documented, as were any reports of noncompliance with weight-bearing restrictions. For patients treated operatively, type of fixation (calcaneal-specific perimeter plate, non-perimeter plate, screw fixation), utilization of locking screws, use of bone graft or graft substitutes, and the number of screws supporting the posterior facet were documented.

Results: ANOVA (analysis of variance) confirmed a statistically significant amount of settling within the operative ($P < 0.001$) and nonoperative ($P < 0.001$) groups but no statistically significant difference in the average settling of BA between the two groups. The average decrease in BA for the operative and nonoperative group was 8° ($P = 0.80$). Of the different variables examined by multivariable linear regression modeling, older age ($P < 0.001$), diabetes ($P = 0.03$), and alcohol ($P = 0.02$) were significant and independent predictors of the amount of posterior facet settling irrespective of treatment.

Conclusion: The average amount of posterior facet settling was 8°, irrespective of operative or nonoperative treatment. The amount of settling increases with increasing patient age, alcohol abuse, and diabetes. This information can help guide treatment of patients with calcaneus fractures by allowing for a better understanding of the factors that affect posterior facet settling. Appropriate counseling of patients as well as a modification in weight-bearing protocols in certain patient populations may be warranted.

Functional Outcomes of Minimally Invasive Versus Extensile Lateral Approach for Intra-Articular Calcaneus Fractures

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Background/Purpose: Treatment of calcaneus fractures carries a high rate of soft-tissue complications when they are treated operatively. Studies have shown that displaced intra-operative calcaneus fractures do better functionally when they are treated with open reduction and internal fixation versus nonoperative treatment. Minimally invasive approaches have recently been adapted to the calcaneus to decrease the soft-tissue complications while providing improved functional scores compared to nonoperative fixation. We hypothesized that patients treated with a minimally invasive (MI) approach versus a traditional extensile lateral (EXT) approach would have comparable functional outcomes with improved complication rates.

Methods: 44 charts were retrospectively reviewed for patients with a displaced intra-articular calcaneus fractures treated operatively with either a minimally invasive or a traditional lateral extensile approach. Demographic data were collected, as well as Short Musculoskeletal Function Assessment (SMFA) scores, infection rate, reoperation rate, incisional complications, final range of motion, and time to weight bearing.

Results: 26 patients were treated with a minimally invasive approach and 18 were treated with an extensile lateral approach. Demographic data showed no difference with the exception of follow-up, where the extensile lateral group had significantly longer follow-up (28.8 vs 73.06 months, P <0.01). SMFA functional scores showed no difference between the two groups for dysfunction (11.73 vs 14.56, P = 0.48), bother (13.58 vs 16.72, P = 0.56), or raw (12.54 vs 17.75, P = 0.52) scores. The minimally invasive approach had a decreased reoperation rate versus the extensile lateral group (19.2% vs 50%, P = 0.049). The minimally invasive group was also quicker to bear weight than the extensile group (12.94 vs 15 weeks, P = 0.01).

Conclusion: When comparing the functional scores of patients with an intra-articular calcaneus fracture treated with either a minimally invasive approach versus a traditional extensile lateral approach, preliminary data show no significance difference between the two treatment approaches. The minimally invasive group did show quicker time to full weight bearing. The minimally invasive group also had a lower reoperation rate compared to the extensile lateral group, but the lateral approach group had significantly longer follow-up.

See pages 47 - 108 for financial disclosure information.

Table 1
Demographics

	All (Mean ± SD)	MI (Mean ± SD)	EXT (Mean ± SD)	p-value
Age (years)	54.3±10.6	54.7±10.1	58.0±49.8	0.74
Follow up (months)	47.0±27.7	28.88±15.48	73.06±19.24	<.01
	No. (%)	**No. (%)**	**No. (%)**	
Male	33/44 (75)	19/26 (73.1)	14/18 (77.8)	1.0
Closed	39/44 (89)	23/26 (88.5)	16/18 (88.9)	1.0
Classification				
Sander's II	13/44 (30)	8/26 (30.8)	5/18 (27.8)	0.70
Sander's III	16/44 (36)	9/26 (34.6)	7/18 (38.9)	0.70
Sander's IV	1/44 (2)	0/26 (0.0)	1/18 (5.6)	0.70
Unknown	14/44 (32)	9/26 (34.6)	5/18 (27.8)	0.70

Table 2
Clinical Outcomes

	MI (%)	EXT (%)	p-value
Infection	0/26 (0.0)	1/18 (5.6)	0.41
Incisional Complications	1/25 (4.0)	3/18 (6.7)	0.29
Reoperation	5/26 (19.2)	9/18 (50)	0.049

Table 3
Functional Outcomes

	MI	EXT	p-value
Dysfunction	11.73±12.53	14.56±13.32	0 .48
Bother	13.58±16.33	16.72±17.92	0.56
Raw	12.54±13.36	17.75±12.5	0.52
Range of Motion	72.5°±15.05	58.06°±33.57	0.10
Weight Bearing (weeks)	12.94±2.62	15±2.47	0.01

Modification of the Distal Tibiofibular Relationship of the Normal Ankle in Plantar Flexion and Dorsiflexion Measured on MRI

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Purpose: Classically, the position of the foot was thought to be important during reduction and fixation of a syndesmotic injury to avoid loss of dorsiflexion. Even if most cadaveric studies showed that the tibiofibular mediolateral distance increase in dorsiflexion, Tornetta et al showed that the position of the foot did not impact ankle dorsiflexion as long as the syndesmosis was anatomically reduced. A validated measurement system was previously developed to describe the distal tibiofibular joint on both MRI and CT scan. The purpose of this study was to evaluate the impact of the position of the foot in the sagittal plane (dorsiflexion [DF], plantar flexion [PF]) on the syndesmosis using this measurement system.

Methods: 34 volunteers were recruited and had a series of ankle MRI scans in three different ankle positions: dorsiflexion, plantar flexion, and neutral position. Inclusion criteria were no previous ankle injuries and no contraindication to MRI examination. Three different holders were designed to keep the ankle stable in the 3 positions. Measurements (6 translational measurements and 2 angles) were then taken on each of the three sets of MRI scans. Paired t tests were done to establish significant differences between measurements.

Results: The mean angle between the leg and the foot for the three positions were 152° ± 8° for plantar flexion, 95° ± 3° for neutral position, and 80° ± 5° for dorsiflexion, and this was significantly different. The first set of analyses was between PF and DF. The distance between the most anterior point of the incisura and the nearest most anterior point of the fibula varied from 2.5 mm (PF) to 3.9 mm (DF) ($P < 0.0001$). The same posterior measurement was not significant. The fibular angle also changed from 8.7° (PF) to 7.8° (DF) of internal rotation ($P = 0.046$). The distance between the tibia and the fibula in the middle of the incisura was 1.5 mm in PF and increased to 2.6 mm in DF ($P < 0.0001$). In the anteroposterior plane, there was a significant anterior displacement of the fibular in the incisura of 0.4 mm ($P = 0.007$ and $P = 0.037$). Those differences were essentially from PF to neutral position. The only parameter increase of 0.4 mm from neutral to DF was the anterior distance ($P < 0.002$).

Conclusion: There are significant changes in normal anatomy of syndesmosis between dorsiflexion and plantar flexion. Specifically, there is an increase in external rotation and lateral translation of the fibula. These changes are visible with MRI using a validated measurement system and values are concordant with those reported on cadaveric studies. Taking ankle position into consideration will be important for future research studies that focus on syndesmosis imaging.

See pages 47 - 108 for financial disclosure information.

Efficacy of Immediate Postoperative Pain Control Modalities After Ankle Fracture Fixation: A Multimodal Comparison

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Background/Purpose: Postoperative pain control following orthopaedic extremity fracture surgery continues to be a complex problem. Peripheral nerve blocks, general anesthesia (GETA), and continuous infusion of anesthetic modalities have all been detailed in the literature with varying results. This study sought to contrast the short-term efficacy of these three modalities in controlling postoperative pain for patients undergoing internal fixation for ankle fractures.

Methods: Data from two separate IRB-approved prospective blinded randomized controlled trials were compiled for analysis. In one cohort, 50 patients were consented and randomized to general anesthesia without regional anesthesia (GETA), or general anesthesia with a popliteal sciatic nerve block (SNB). In the second cohort, 50 patients were consented and randomized to receive a single-shot popliteal sciatic nerve block or a popliteal sciatic nerve catheter receiving continuous anesthetic infusion for 48 hours (CNB). In both cohorts, visual analog scale (VAS) pain levels were tracked in the postanesthesia care unit. Pain assessments for comparison were available at the 2, 8, 12, 24, and 48-hour postoperative time points in both cohorts. Chi-square tests were used to compare categorical variables and Student t tests to compare continuous variables between groups.

Results: CNB patients demonstrated significantly lower VAS pain scores at the 2-hour postoperative period compared to the GETA group (P <0.001) and SNB (P <0.001). At the 8-hour

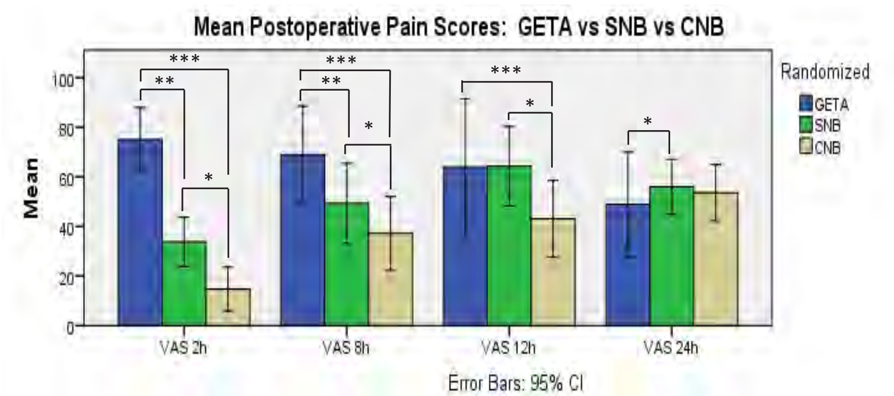

Figure 1: Average visual analog scale pain scores by hours postoperatively for SNB, GETA, and CNBgroups. Asterisk represents statistical significance between groups (p-value<0.05) Error bars represent 95% Confidence Interval.

postoperative period, CNB patients still had significantly lower VAS scores than GETA (P = 0.007). Additionally, CNB patients had significantly lower pain scores at 12 hours compared to SNB (P = 0.015). The SNB group had significantly lower pain scores at the 2-hour time period compared to GETA patients (P <0.001), but higher scores at the 24-hour period (P = 0.045). At all postoperative time points mean postoperative pain scores were lower in the CNB group versus the SNB and GETA groups.

Conclusion: Patients treated with continued infused regional anesthestic for pain control experienced less pain in the first 12 hours than GETA and SNB patients in this study. While an SNB and CNB infusion are superior modalities compared to GETA for immediate postoperative pain control at 2 and 8 hours, the SNB group experience a "rebound phenomenon" at 12-24 hours where they have a sudden increase in pain after the block diminishes. By 24 hours, all anesthetic modalities show no clinically significant difference.

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Open Treatment of Ankle Fracture as an Inpatient Increases the Risk of a Complication

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Purpose: Ankle fractures are one of the most common injuries treated by orthopaedic surgeons with a rate of 187 per 100,000. It remains unclear whether there is increased risk of a postoperative complication following inpatient versus outpatient treatment of these injuries. We utilized the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database to compare the 30-day complication rates between inpatient versus outpatient surgical management of ankle fractures.

Methods: Using the ACS-NSQIP database from 2006 to 2013, we conducted a retrospective analysis of prospectively collected patient demographics, comorbidities, and 30-day complications of isolated open treatment of ankle fractures. A propensity-matched dataset using an 8 to 1 greedy matching algorithm in a 1:1 ratio was created to control for differences in preoperative demographics and comorbidities across inpatient and outpatient groups. A multinomial logistic regression model was used to assess the odds of minor (superficial wound infection, pneumonia, and urinary tract infection) and major (deep wound infection, organ space infection, myocardial infarction, stroke, pulmonary embolism, deep venous thrombosis, sepsis, septic shock, and death) postoperative complications within 30 day following open treatment, adjusting for duration of surgery.

Results: 7383 patients were identified with 2630 (36%) in the outpatient and 2630 (36%) in the inpatient group. Overall, 104 (4.0%) inpatients versus 52 (2.0%) outpatients developed a complication (P <0.001). Inpatients developed major complications, including deep wound infection (P = 0.032) and pulmonary embolism (P = 0.004), and minor complications, including superficial wound infection (P = 0.026), pneumonia (P = 0.014), and urinary tract infection (P = 0.027), at a higher rate. As shown in Table 1, inpatient treatment was also associated with increased odds of developing a minor, major, or any complication.

Table 1. Rate of Complications for Inpatients vs. Outpatients with Ankle Fractures

	Minor Complications	Minor: Odds ratio (95% CI, p-value)	Major Complications	Major: Odds ratio (95% CI, p-value)	Total Complications	Total: Odds ratio (95% CI, p-value)
Inpatient (N=2,630, 36%)	68 (2.6%)	1.86 (1.23-2.82) p=0.003	45 (1.7%)	2.14 (1.19-3.82) p=0.011	104 (4.0%)	1.94 (1.39-2.73) p<0.001
Outpatient (N=2,630, 36%)	35 (1.3%)	Reference	20 (0.8 %)	Reference	52 (2.0%)	Reference

Conclusion: Even when controlling for comorbid conditions, undergoing open treatment of an ankle fracture as an inpatient has two-fold increased odds of developing a complication within 30 days. Multivariate analysis corroborates inpatient status as an independent risk factor for such a complication. In a future bundled payment system, orthopaedic trauma surgeons need to be aware of the factors influencing complications.

Predictors of Adverse Events for Ankle Fractures: An Analysis of 6800 Patients

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Purpose: Over the last 30 years, physicians have seen a dramatic increase in the number of ankle injuries due to an active, aging population. Given that ankle fractures are one of the most common fractures seen by orthopaedic surgeons, it is essential that they understand risks associated with their treatment. With the recent expansion of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, we have the opportunity to investigate the rates of minor, major, and all adverse events for a large cohort of ankle fractures.

Methods: Using the ACS-NSQIP database from 2006 to 2013, we collected patient demographics, comorbidities, and 30-day complications for ankle fractures. Current Procedural Terminology (CPT) codes included 27766 (medial malleolus), 27792 (lateral malleolus), 27814 (bimalleolar), 27822 (trimalleolar), and 27823 (trimalleolar with posterior). A univariate analysis was done to compare the patient demographics, comorbidities, and complications across all CPT codes. A multivariable logistic regression model was then used to assess the odds of minor (superficial wound infection, pneumonia, and urinary tract infection) and major (deep wound infection, organ space infection, myocardial infarction, stroke, pulmonary embolism, deep venous thrombosis, sepsis, septic shock, and death) postoperative complications within 30 days following open treatment, adjusting for type of surgery by CPT code and preoperative characteristics.

Results: 6865 patients were included for analysis. As shown in Figure 1, 36.5% (n = 2507) of fractures were bimalleolar ankle fractures, which also presented with a significantly higher American Society of Anesthesiologists (ASA) score compared to the other fracture types (P <0.0001). The overall rate of adverse events for ankle fractures was low. Bimalleolar ankle fractures had the highest rate of major (2.6%, n = 64), minor (3.8%, n = 94), and total complications (5.7%, n = 143). Figure 1 compares the rate of adverse events by type of ankle fracture. When controlling for individual patient characteristics, bimalleolar fractures were 4.92 times (95% confidence interval [CI] 1.80-13.5, P = 0.002) more likely to develop a complication as a medial malleolus fracture. Risk factors driving the higher rate of complications for bimalleolar fractures were found to be age over 65 years, male gender, diabetes, history of chronic obstructive pulmonary disease (COPD), history of congestive heart failure (CHF), ASA score greater than 2, and dependent functional status (P <0.0001).

Conclusion: Our data demonstrate that even though there is an overall low rate of adverse events for ankle fractures, bimalleolar fractures are about 5 times more likely to develop any complication. As we shift into a bundled payment system, orthopaedic surgeons must be aware of the risk factors that increase the rate of ankle fracture complications in order to provide quality care and reduce costs for one of the most common types of injuries.

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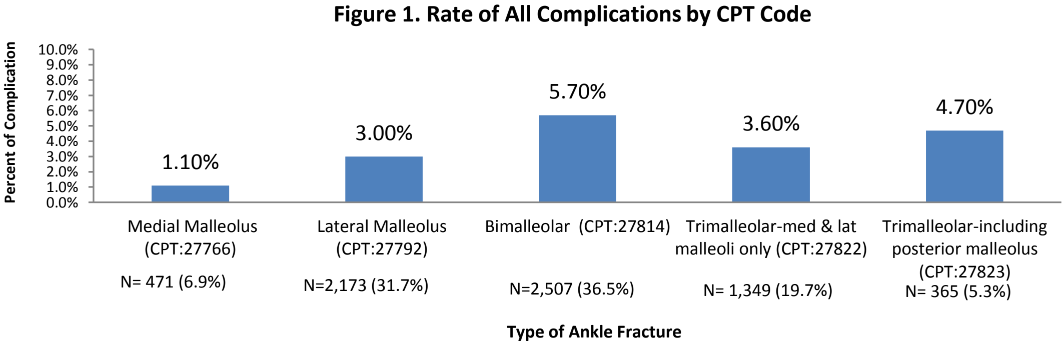
Predictors of Adverse Events for Ankle Fractures: An Analysis of 6,800 Patients



POSTER ABSTRACTS

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.

A Novel Method to Quantify Ankle Soft-Tissue Envelope and its Association with Surgical Site Infections After Open Reduction and Internal Fixation of Unstable Ankle Fractures

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Background/Purpose: Unstable ankle fractures are common injuries seen in adults. The orthopaedic standard of care often involves open reduction and internal fixation (ORIF); however, unintended complications can arise, specifically surgical site infections (SSI). SSI can have a significant impact on patient quality of life, functional outcomes, and overall health-care costs and resource utilization. The soft-tissue envelope (STE) size may alter the patient's risk for SSI and ability to heal. To date, the associate between STE or body mass index (BMI) and ankle SSI after ORIF has not been extensively studied. In addition, a patient's weight/BMI may not be indicative of the size or quality of the STE surrounding the injured ankle. The aim of our study was to examine the association between STE and/or BMI and SSI following ORIF of unstable ankle fractures, as well as identify other potential patient-specific risk factors.

Methods: After IRB approval, we conducted a retrospective review of 499 patients who underwent ankle ORIF for unstable ankle fractures by multiple surgeons at a single institution. Radiographic measurements were performed at the time of injury, 3 months, and 6 months postoperatively. Coronal, sagittal, and cumulative STE measurements were recorded as shown in Figure 1. Relative ratios of the STE to the tibial plafond cortical diameter (TCD) served as an internal control to magnification variability. BMI to TCD ratio was also calculated. Age, gender, mechanism of injury, fracture classification, smoking status, medical comorbidities, type of fixation used, operating room metrics, infection management, and ultimate patient outcome were recorded. Descriptive statistics were undertaken to characterize patient cohorts. Univariate logistic regression was utilized to produce crude odds ratios and 95% confidence intervals, and all possible predictors with a univariate P value of <0.2 were considered for inclusion in a multivariable model to obtain adjusted odds ratios. Statistical significance was set at P <0.05.

Results: STE size (total STE) was significantly larger in the infected cohort of patients. At the time of injury, the only significant difference was shown in the coronal measurements: 49.1 versus 45.1 mm (infected vs non-infected) (P = 0.022). At 3 and 6 months, coronal, sagittal, and cumulative STE (sum of sagittal and coronal measurements) were all significantly greater in the infected cohort. For example, cumulative STE showed a difference of 47.4 versus 40.9 mm at 3 months (P = 0.003) and 49.7 versus 40.0 mm at 6 months (P <0.001). Similarly, the infection group demonstrated significant STE to TCD ratios, with 1.1 versus 1.0 (P = 0.027) on mortise view, 1.4 versus 1.3 (P = 0.045) total STE:TCD, and 1.5 versus 1.3 (P = 0.003) total STE:TCD at all 3 intervals, respectively. Patients who developed an infection after ankle ORIF showed a statistically significantly higher incidence of diabetes mellitus (DM), hypertension (HTN), coronary artery disease (CAD), and peripheral vascular disease

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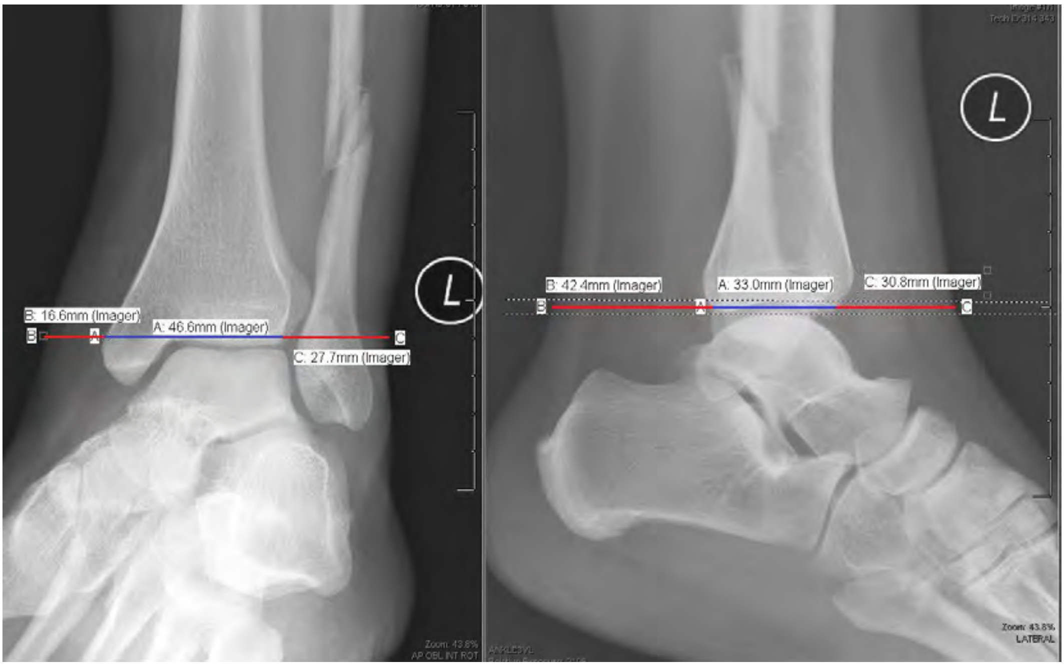
(PVD). Infection was also correlated with longer mean surgical time, 117.5 versus 106.7 minutes (P = 0.046). Of note, BMI did not show statistical significance.

Conclusion: In this study, we describe a novel measurement tool for evaluating the ankle soft-tissue envelope. Our findings suggest that STE size is a significant risk factor for developing surgical site infection, with significance at 3 and 6 months with all measurements. In examining preoperative radiographs, only the coronal (mortise view) measurements showed statistical significance. This may be due to wide variability in radiographs seen from emergency departments, urgent care facilities, and outside clinics. With more consistent technique at follow-up in a single-site clinic, the 3 and 6-month radiographs showed much less variability. Prospective studies would help to confirm this association and to further quantify the risk associated with increasing STE. In addition, our study has shown strong associations between SSI and immunocompromised and vasculopathic states, including DM, HTN, CAD, and PVD. This study helps to further support the value of a healthy ankle STE when considering fracture surgery. This novel tool allows surgeons to better counsel patients on their risk of developing an SSI.



POSTER ABSTRACTS

Improving Outcomes in Patients with Ankle and Hindfoot Fusions Following Trauma

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Background/Purpose: Fractures of the distal tibia, ankle, and foot sustained through high-energy mechanisms can be extremely debilitating, and ankle and/or subtalar fusion may be indicated if the limb is deemed salvageable. Functional outcomes among this population are generally poor. Recently, the integration of a novel, carbon-fiber orthosis with a specialized rehabilitation regimen has shown promise in improving physical performance measures among a cohort of patients with a variety of lower extremity injuries. However, the benefit of this combined program on patients with ankle and/or hindfoot fusion is unknown.

Methods: We conducted a prospective, longitudinal, observational cohort study. This is subgroup analysis of a larger study previously conducted at our institution of 23 active-duty service members treated for lower extremity trauma in the Return to Run clinical pathway (RTR CP) between January 30, 2012 and December 20, 2012. The 23 patients in this series had 9 ankle fusions, 11 subtalar fusions, 2 unilateral ankle and subtalar fusions, and 1 bilateral ankle fusion. For the purposes of comparison, patients were separated into two groups; Group 1 was comprised of 12 patients with isolated ankle fusions or ankle fusion combined with ipsilateral subtalar fusion, and Group 2 was comprised of 11 patients with subtalar fusion only. The RTR CP consists of two rehabilitation phases: an initial out-of-brace phase (4 weeks) followed by an in-brace phase (4 weeks). Patient-reported outcome measures included the Short Musculoskeletal Function Assessment (SMFA), the Veterans Rand 12-item health survey (VR-12), and the visual analog pain scale (VAS). Physical performance was assessed using four validated outcome measures: the four-square step test (FSST), self-selected walking velocity (SSWV), timed stair ascent, and the 20-meter shuttle run. Outcomes data were collected at program initiation (week 0), week 5, and week 8. A one-way analysis of variance (ANOVA) with repeated measures was used to examine the change in each of the physical performance measures and patient-reported outcomes during the course of the study. A two-way ANOVA with repeated measures and the Tukey-Kramer adjustment for multiple comparisons were used to determine if there were differences in the rate and magnitude of improvement in the scores in each of the physical performance measures. SAS 9.2 was used for all statistical analysis. Statistical significance was set at $P < 0.05$.

Results: Significant improvements in both groups were seen in each of the four physical performance measures between week 5 to week 8 and from week 0 to week 8. No significant improvement in these same measures was observed in either group between week 0 and week 5 (Tables 1 and 2). While there was no significant difference in VAS values between Groups 1 and 2 at week 0 (4.0 vs 5.1, $P = 0.60$), there was a significant decrease in pain as represented by the VAS among Group 2 from week 0 to week 8 (5.1 to 2.3, $P < 0.0001$). Regarding SMFA results, Group 1 did not demonstrate any significant change in these values throughout the RTR CP. Conversely, Group 2 demonstrated significant improvements in all domains, except for arm and hand function, between week 5 to 8 and week 0 to 8. With

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respect to VR-12 results, Group 2 demonstrated significant improvements in physical component summary scores from weeks 5 to 8 and week 0-8. Additionally, Group 2 improved in the mental health component summary score from week 0 to 5, prior to the addition of the IDEO (Intrepid Dynamic Exoskeletal Orthosis). Group 2 also showed improvement in the mental health component summary score at the 8-week point (47.5 to 53.7, P = 0.04).

Conclusion: Patients treated with either isolated subtalar fusion, ankle fusion alone, or in combination with subtalar fusion who completed 8 weeks of the RTR CP showed significant improvements in physical performance and patient-derived outcome measures. These promising short-term results may be of particular importance to a specific group of patients previously thought to be destined for suboptimal clinical and functional outcomes.

Table 1. Group 1 Physical Performance Measures				P value		
	Week 0	Week 4	Week 8	Week 0 - 4	Week 4-8	Week 0-8
Four Square Step Test (s)	8.8	8	6.1	ns	< 0.0001	<0.0001
Self-Selected Walking Velocity (m/s)	1.2	1.3	1.5	ns	<0.0001	<0.0001
Timed Stair Ascent (s)	6.6	5.9	4.3	ns	0.009	<0.0001
Shuttle Run (s)	11.9	10.9	7.8	ns	<0.0001	<0.0001

Table 2. Group 2 Physical Performance Measures				P value		
	Week 0	Week 4	Week 8	Week 0 - 4	Week 4-8	Week 0-8
Four Square Step Test (s)	8.3	8.8	5.7	ns	<0.0001	<0.0001
Self-Selected Walking Velocity (m/s)	1.2	1.2	1.4	ns	0.0002	<0.0001
Timed Stair Ascent (s)	6.9	7.5	3.9	ns	<0.0001	<0.0001
Shuttle Run (s)	12.5	12.9	6.6	ns	<0.0001	<0.001

Incidence of Preoperative Deep Vein Thrombosis in Isolated Calcaneal Fractures

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Background/Purpose: Calcaneal fractures are a complex injury that can lead to significant morbidity despite surgical treatment. The most common cause of postoperative morbidity is early operative intervention through a damaged soft-tissue envelope. To limit those risks, calcaneal fracture surgical intervention is often delayed 7-10 days until the soft-tissue envelope is deemed safe. This prolonged period of extremity elevation and limited mobility may place patients at increased risk for the development of deep vein thrombosis (DVT) both pre- and postoperatively. This study examines the incidence and risk factors of preoperative DVT in patients presenting to an outpatient setting with an isolated calcaneal fracture who have all undergone preoperative duplex ultrasonography.

Methods: This is an IRB-approved retrospective review of all isolated calcaneal fractures treated as an outpatient at a regional Level I trauma center from 2005-2013. All patients included were over the age of 18 years, had a preoperative duplex ultrasonography of bilateral lower extremities per the treating surgeon's protocol, and had at minimum 6 weeks follow-up. Patients were excluded if they were polytrauma patients, had a documented hypercoagulable state, or were on baseline pharmacologic anticoagulation for another condition. We compared the rate of DVT in our study to that of the three similar prospective DVT diagnostic studies, using the binomial probability for small sample size test. Multiple logistic regression was also performed with the presence or absence of a DVT as the outcome variable, and the patient or injury characteristics as the predictor variables. All analyses were performed with Stata software (StataCorp) and statistical significance was established using $P < 0.05$.

Results: 160 (114 male, 46 female) isolated calcaneus fracture patients qualified for our study (Table 1). The mean age was 46.4 years (range, 18-77). The mean BMI (body mass index) was 26.2 kg/m2 (range, 17.9-42.1) and the mean time to surgery was 19.5 days (range, 1-105). 19 patients (16 males and 3 females; 12%) had a DVT preoperatively. All of the DVTs were in the operative extremity with the exception of one patient who had bilateral DVTs. The average time to surgery for the patients who had a DVT was 23.6 days (range, 11-105). There were 10 peroneal vein DVTs, followed by 6 soleal, 2 posterior tibial, and 1 intramuscular calf veins (Table 2). Seven patients had DVTs in multiple veins in the leg. One patient required inferior vena cava filter placement (IVC), while the remainder were treated with Lovenox or Coumadin. The proportion of calcaneal patients with DVT in our study (12%) is significantly different from the rates reported in the literature (5% to 6.5%) for foot and ankle trauma ($P < 0.01$). Older age was found to be the only risk factor for DVT ($P = 0.009$, odds ratio = 1.06).

Conclusion: The incidence of preoperative DVT found here is almost 2 times as high as any previously published examination of lower extremity injuries. Both physicians and their patients should be aware of the risk of preoperative DVT with isolated calcaneal fractures.

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	Patients without DVT	Patients with DVT
Male:Female	98:43	16:3
Age	45.4 (18-77)yrs	53.4 (25-74)yrs
BMI	26.5 (18.7-41.6)kg/m^2	23.4 (18.5-33.3)kg/m^2
Time to Surgery	18.9 (1-102)days	23.6 (11-105)days
Fracture Classification		
73A	1	1
73B	15	0
73C	94	12
73NFS	8	0

Table 1. Demographic data of patients with isolated calcaneal fractures with and without preoperative DVT.

Distribution of DVTs	
Peroneal vein	10
Soleal vein	6
Intramuscular calf veins	5
Posterior tibial vein	4
Gastroc vein	2
Popliteal vein	1
Femoral vein	1

Table 2. Location of the DVTs found in patients prior to surgical fixation of isolated calcaneal fractures.

Early Weight Bearing After Fracture Fixation Does Not Affect Fracture Healing or Loss of Fixation Compared With Non-Weight Bearing

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Background/Purpose: Acute ankle fractures treated with operative fixation commonly results in 6 weeks of non-weight bearing (NWB). Our goal was to determine if early weight bearing (EWB) affected fracture healing, loss of fixation, wound complication, and return to work compared with at least 6 weeks of NWB after fracture fixation.

Methods: Consecutive patients operated on for AO classification 44B or C fractures with and without syndesmotic injuries were included in the analysis. Exclusions were those <18 years old, with preexisting neuropathy, diabetes, or concomitant injury precluding EWB (ie, ipsilateral tibial plateau fracture). EWB was defined as weight bearing as tolerated 2 weeks post fixation. These patients were placed in a postoperative controlled ankle movement boot and instructed to weight-bear as tolerated. EWB patients were treated by a single physician and data from the NWB cohort came from 4 others, all fellowship-trained orthopaedic trauma surgeons. Total implant counts were derived from radiographic images immediately postoperative. All other data extraction occurred via chart review.

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Results: A total of 116 patients qualified for study. The EWB (n = 37) and NWB (n = 79) groups had no statistically significant differences in demographics, fracture type, total hardware implanted (8.62 vs 9.25, P = 0.304), days to return to work (146 vs 155, P = 0.778), wound complication (3 vs 10, P = 0.546), reoperation rates, time to reoperation, or days to union (149 vs 117, P = 0.151). While there was no difference in the rates of return to surgery for loss of fixation, EWB patient trended toward earlier return to surgery. Further subgroup analysis for open fractures (n = 10) also revealed no statistically significant difference in wound complication (P = 1.00).

Conclusion: Successful treatment of 44B or C ankle fractures is possible using both EWB and NWB protocols. EWB had no obvious positive effect on return to work or days to union, nor did it appear to increase the risk of fixation failure. However, our data did indicate a trend to earlier reoperation in the EWB group. This suggests patients with constructs doomed to fail may fail sooner with EWB, which may offer the benefit of earlier corrective operations, allowing the patient to progress sooner toward full recovery.

See pages 47 - 108 for financial disclosure information.

Determinants of Functional Outcome After Operative Calcaneus Fractures

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Purpose: Intra-articular calcaneus fractures are associated with a high frequency of complications and secondary procedures, as well as functional limitations in previous literature. The purpose of this study was to assess patient injury, medical, social, and treatment characteristics to identify associations with functional outcomes in orthopedic patients treated surgically for intra-articular calcaneus fracture. We propose to identify factors predictive of better outcome.

Methods: Over 12 years 96 adult patients with 109 intra-articular calcaneus fractures were treated surgically by a single surgeon. Functional outcomes were measured with Foot Function Index (FFI) and Musculoskeletal Function Assessment (MFA) surveys. The FFI is an extremity-specific score for foot and ankle function, with subscores for pain, disability, and activity, each scaled up to 100 points. The total FFI score is the average of the 3 subscores. The MFA is a generalized survey, scaled from 1 to 100 points. Lower FFI and MFA scores indicate better function.

Results: 60 patients with 67 fractures completed surveys (63%) after a mean of 75 months (minimum 12 months) follow-up, including 45 men and 15 women with mean age 43.4 years. 11 (18%) had open fractures, and 28 (47%) were tobacco smokers. 41 fractures (61%) were treated with open reduction and external fixation (ORIF) using an extensile lateral approach, and 26 had percutaneous reduction and fixation. At most recent follow-up 22% had radiographic evidence of posttraumatic arthrosis (PTA), occurring in 27% of patients after ORIF and 13% after percutaneous treatment. Overall, 72% of patients had returned to employment. Mean MFA of all patients was 27.2, and mean total FFI was 31.1, indicating substantial residual dysfunction when compared with a normal, uninjured population (mean 12.0 and 9.0, respectively, P <0.0001). Men had worse FFI scores than women (33.7 vs 22.6, P = 0.031) but similar MFA scores. Patients treated with ORIF had better MFA (24.1 vs 31.7, P = 0.13) and FFI scores (24.8 vs 41.2, P = 0.015) when compared with percutaneous fixation. Presence of PTA was associated with higher mean MFA (34.4 vs 25.1, P = 0.12) and FFI scores (38.6 vs 29.4, P = 0.27). Age, medical illness, and fracture pattern were not associated with outcomes. However, patients with a history of alcohol abuse had worse FFI scores (50.9 vs 28.4, P = 0.021), and patients who were unemployed after injury had worse MFA (34.5 vs 24.3, P = 0.069) and FFI scores (42.1 vs 26.9, P = 0.034).

Conclusion: After mean follow-up of 75 months, patients who sustained intra-articular calcaneus fractures had substantial residual dysfunction on both generalized and foot-specific outcome surveys. With the numbers available, patients treated with percutaneous reduction and fixation had less PTA but worse FFI scores. Worse outcomes were associated with male gender, alcohol abuse, and unemployed status. Patients who never returned to work had the worst MFA and FFI scores, indicating an opportunity to intervene with vocational rehabilitation and counseling strategies.

CT Assessment of Peroneal Tendon Displacement and Posteromedial Structure Entrapment in Pilon Fractures

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Background/Purpose: Pilon fractures are often associated with significant damage to the articular surface of the tibial plafond and surrounding soft tissue. The objective of this study was to analyze a cohort of patients that sustained pilon fractures and determine (1) the prevalence of peroneal tendon displacement and posteromedial soft-tissue interposition accompanying these high-energy injuries, (2) association of peroneal tendon displacement and posteromedial structure entrapment with OTA/AO fracture classification and concomitant fibular fractures, and (3) the rate of missed diagnosis of peroneal tendon displacement and posteromedial structure entrapment based on interpretation of CT. We hypothesized that the prevalence of peroneal tendon displacement and posteromedial soft-tissue entrapment increases with fracture severity and the presence of a concomitant fibular fracture, and that the diagnosis was frequently missed.

Methods: This was a retrospective radiographic review of pilon fractures treated between July 2008 and November 2014. Radiographs and CT images of 200 pilon fractures before definitive fixation were available for review. Fractures were classified as OTA/AO types 43-A, B, or C and concomitant fibula fractures were identified. Bone and soft-tissue windows of axial and reconstructed CT images were used to determine (1) peroneal tendon subluxation/dislocation or avulsion of the superior peroneal retinaculum, and (2) posteromedial soft-tissue interposition within the fracture site. Medical charts were reviewed for documentation of either injury in final radiology reports.

Results: Peroneal tendon displacement was present in 22/200 (11%) fractures reviewed. Posteromedial structure entrapment was present in 38/200 (19%) fractures reviewed, with the tibialis posterior tendon interposed most frequently in 33/38 (87%), and often even after provisional external fixation. The prevalence of peroneal tendon displacement and posteromedial soft-tissue interposition was highest in complete articular fractures (OTA/AO type 43-C) at 15% and 25%, respectively. In complete articular fractures with an ipsilateral fibular fracture, peroneal tendon displacement occurred in 11%. In complete articular fractures without an ipsilateral fibular fracture, peroneal tendon displacement occurred in 35%. Only 11/22 (50%) cases of peroneal tendon displacement and 19/38 (50%) cases of posteromedial soft-tissue interposition were documented in final radiology reports.

Conclusion: This study further demonstrates that CT imaging of pilon fractures can be instrumental in identifying injury to surrounding soft-tissue structures. Peroneal tendon displacement and posteromedial structure entrapment is most prevalent in severe injuries to the tibial plafond classified as OTA/AO type 43-C fractures. Our study suggests that when an ipsilateral fibula fracture is present, peroneal tendon displacement is less common. The presence of these injuries are commonly overlooked, which may result in unnecessary

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morbidity, such as difficult or failed reduction and need for additional surgery. Radiologists and orthopaedic surgeons should be mindful of these concomitant injuries when evaluating and treating pilon fractures.

Anatomic Syndesmotic Reduction: Using Intraoperative Fluoroscopic Imaging to Ensure Accurate Clamp Position

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Background/Purpose: Ankle fractures are one of the most common injuries managed by orthopaedic surgeons, many of which have concomitant syndesmotic disruption. Numerous studies indicate that syndesmotic malreduction portends poorer prognosis in pain and function scores. The most common technique for syndesmotic reduction involves reduction forceps with fluoroscopic assessment. However, reports of malreduction range from 12% to 52%. This is likely due to eccentric clamp placement leading to translation or rotation of the fibula within the incisura. In the current study we sought to determine the true "trans-syndesmotic axis" (TSA) that could subsequently be used to describe a reliable technique to perform anatomic clamp reduction of the syndesmosis using intraoperative fluoroscopy.

Methods: CT scans of uninjured lower extremities were analyzed to measure the TSA in 45 adult patients. This angle was measured 1 cm proximal to the tibiotalar joint and was defined as the angle between the plane of a lateral ankle radiograph and a line perpendicular to the distal tibial incisura. Three-dimensional (3D) reconstructions of the CT scans were generated using Vitrea Core software and were used to demonstrate clamp placement collinear with the patients' true syndesmotic angles at 1 cm proximal to the tibiotalar joint line. The 3D reformats with anatomic clamp placement were used to study clamp appearance as would be seen on intraoperative lateral ankle fluoroscopy.

Results: The average syndesmotic angle measured 21° ± 5°. When the position of the reduction clamp was simulated on the 3D reconstructions, the lateral tine was placed on the fibular ridge and the clamp was oriented along the TSA. The medial tine was, on average, 23% ± 7% of the distance from the anterior tibial cortex to the posterior tibial cortex and was within the anterior one-third of the tibia 93% of the time. When referencing the anterior cortex of the fibula, the medial tine rested 53% ± 17% of the distance between the anterior cortex of the tibia and the anterior cortex of the fibula. The medial tine was within the central third of this space 71% of the time.

Conclusion: Ankle fractures with syndesmotic disruption are associated with a poorer prognosis than those without such an injury. Despite the importance of anatomic reduction of the syndesmosis to optimize recovery, malreduction is common. These results demonstrate that despite variability in the anatomy of the ankle syndesmosis, routine intraoperative use of a true lateral fluoroscopic view can guide clamp placement based on the TSA, and thereby minimize the risk of malreduction. Placing the medial clamp tine in the anterior third of the tibial length, or halfway between the anterior tibial cortex and anterior fibular cortex, appears to be the most accurate position for reduction.

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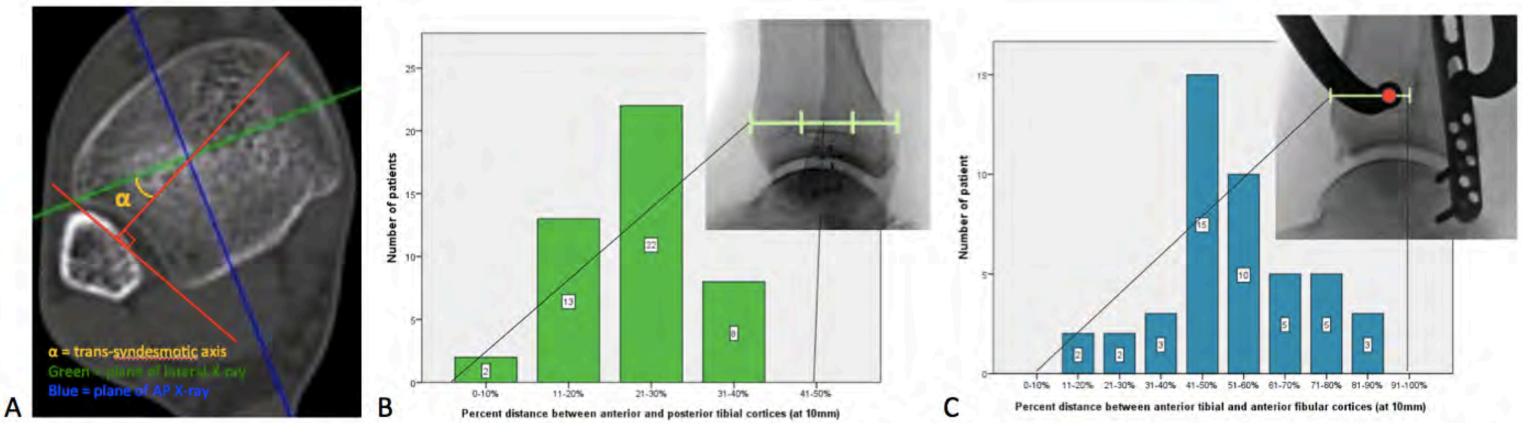

Figure 1. The trans-syndesmotic axis (TSA) was measured (A) on an axial CT at 10 mm proximal to the joint line. Using a three-dimensional reconstruction, the lateral tine of a reduction forceps was positioned on the lateral fibular ridge, and, with the clamp positioned along the TSA, the location of the medial tine on a simulated lateral fluoroscopy image was noted with respect to its position (B) from anterior to posterior along the tibia and (C) in the space between the anterior cortices of the tibia and fibula.

Operative Repair of Proximal Humerus Fractures in Septuagenarians and Octogenarians: How Old is too Old?

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Purpose: With an expected doubling of the geriatric population within the next 30 years it is becoming increasingly important to determine which elderly populations benefit from orthopaedic interventions. This study assesses postoperative outcomes in patients aged 70 years or greater with a proximal humerus fracture treated surgically in an attempt to enhance understanding of long-term outcomes in this patient population.

Methods: A retrospective chart review was conducted for 201 patients with fractures of the proximal humerus (OTA 11A-C) treated operatively by a single surgeon with open reduction and internal fixation. Data from 132 independent, active patients aged 55 years or older was identified and analyzed. 7 patients were excluded due to lack of sufficient follow-up. 47 patients age 70 years or older with proximal humerus fractures were identified with a mean age of 78 ± 5 years. Average length of follow-up was 19 months with follow-up ranging from 6 to 63 months. These patients were compared to a cohort of 78 patients aged 55-69 years with a mean age of 62 ± 3 years and average length of follow-up of 20 months (range, 6-72). All complications were recorded. Univariate analysis was conducted to assess for differences in DASH (Disabilities of the Arm, Shoulder and Hand) scores, range of motion, fracture severity, CCI (Charlson Comorbitidy Index), and demographic information.

Results: 92% of patients achieved fracture union within 6 months. No significant differences were found between cohorts with regard to gender, fracture severity, or CCI (P = 0.197, P = 0.276, P = 0.084, respectively). DASH scores for patients aged 70 and older did not differ from patients age 55-69. No differences in shoulder range of motion were identified. There was no difference in complication rates either, with 10 complications in the older elderly cohort (21%), 6 of which required reoperation and 13 complications in the young elderly cohort (17%), 8 of which required reoperation.

Conclusion: Operative fracture repair using locked plating of the proximal humerus in septuagenarians and octogenarians can provide for excellent long-term outcomes in appropriately selected patients. These patients tend to have long-term functional outcome scores, postoperative range of motion, and complication rates that are comparable to younger geriatric patients. Physicians should not exclude patients for repair of proximal humerus fractures based on chronological age cutoffs.

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Bisphosphonate-Associated Periprosthetic Fractures: A Multicenter Retrospective Review of a New Cause of Periprosthetic Stress Fractures

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Background/Purpose: There is increasing evidence that an association exists between long-term bisphosphonate use and atypical femoral fractures. The American Society of Bone and Mineral Research (ASBMR) Task Force Criteria excluded periprosthetic fractures from the definition of atypical femoral fractures as there was just not enough known at that time to include this group as bisphosphonate fractures. However, case reports have begun to appear in the literature describing patients on long-term bisphosphonate therapy presenting with impending or complete periprosthetic fractures that are radiographically identical to atypical femoral fractures. We present the largest case series of periprosthetic fractures in patients on long-term bisphosphonate therapy. We sought to define the characteristics of periprosthetic fractures in patients on long-term bisphosphonate treatment and to compare and note the similarities of these characteristics with a cohort of patients with atypical femoral fractures. The secondary aim is to note how these fractures differ from the usual periprosthetic fracture presentation and provide a consensus guide to the diagnosis and long-term treatment of these patients.

Methods: All bisphosphonate-related fractures documented in 15 centers over a 10-year period were reviewed in detail. IRB approval was obtained independently at each center. For inclusion, patients had to meet the ASBMR Task Force radiographic criteria for atypical fracture and be treated with long-term bisphosphonates prior to fracture. Fractures had to be operatively treated and followed up for at least 6 months or to union or revision. Periprosthetic fractures were also included. Data collected included patient demographics, medication history, history of prodromal pain, mechanism of injury, and fracture characteristics. Complications such as pneumonia, myocardial infarction, pulmonary embolism, wound infections, and death were recorded as well as revision surgery and time to union.

Results: 191 patients with atypical femur fractures (AFFs) were identified, including 21 with bisphosphonate-associated periprosthetic fractures (BAPPFs). The prodromal pain prior to an acute fracture occurring in all 21 fractures was dramatically different from the usual periprosthetic fracture. In the AFF group, there were 14 males and 161 females (8% and 92% of the atypical fractures). The BAPPF group included two males and 19 females. The average age for the periprosthetic group was 80 years, which was slightly older than the average of 72 years for AFF. 83% of the AFF group was Caucasian, which is very similar to the 82% observed in the BAPPF group. Only a small percentage of this population had suffered prior fragility fractures (AFF = 19% and BAPPF = 18%). Patients had a higher body

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mass index in the BAPPF group versus the AFF group (33 vs 28). Treatment with bisphosphonates was discontinued in 55% of the AFF patients following diagnosis, while treatment was discontinued in only 12% of the BAPPF group. The mortality and complications were similar to that seen in periprosthetic fractures without bisphosphonate treatment. The difference in atypical versus typical periprosthetic fractures was the significantly long prodromal pain prior to fracture. Based on our review we developed an algorithm in conjunction with our endocrine and rheumatologic colleagues to help in decision making when dealing with this rare presentation (see figure).

Conclusion: Examination of the available evidence suggests that periprosthetic fractures in patients on long-term bisphosphonates should be considered a subset of atypical bisphosphonate-associated femoral fractures. This has very significant implications for early clinical decisions in terms of diagnosis, weight-bearing protocols, and prophylactic/treatment and surgical intervention. This is the largest case series of periprosthetic fractures in patients on long-term bisphosphonate therapy. We postulate that this case series will be compelling evidence to alter the task force's position and accept that BAPPFs are indeed a subset of AFFs. As such, these fractures pose serious treatment challenges to trauma and arthroplasty surgeons in terms of diagnosis plus short and long-term management. This study suggests diagnostic aids similar to those for AFFs may be important adjuncts for a patient on bisphosphonates.

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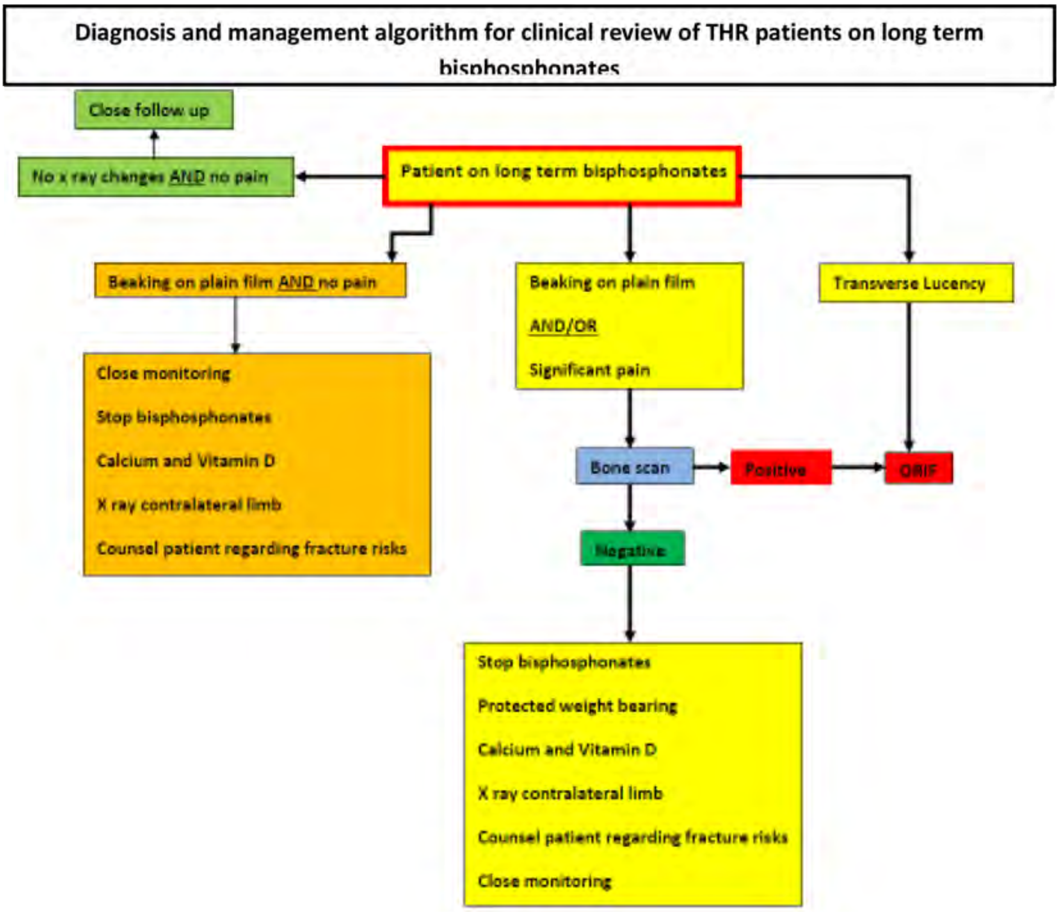
Diagnosis and management algorithm for clinical review of THR patients on long term bisphosphonates
Close follow up
No x ray changes AND no pain
Patient on long term bisphosphonates
Beaking on plain film AND no pain
Beaking on plain film
AND/OR
Significant pain
Transverse Lucency
Close monitoring
Stop bisphosphonates
Calcium and Vitamin D
X ray contralateral limb
Counsel patient regarding fracture risks
Bone scan
Positive
ORIF
Negative
Stop bisphosphonates
Protected weight bearing
Calcium and Vitamin D
X ray contralateral limb
Counsel patient regarding fracture risks
Close monitoring

**Total Hip Arthroplasty for Femoral Neck Fractures:
Does Hospital Arthroplasty Volume Influence Outcomes?**

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Purpose: Total hip arthroplasty (THA) is an increasingly common treatment option for select patients who sustain displaced femoral neck fractures. Primary arthroplasty literature has demonstrated improved THA outcomes at high-volume arthroplasty hospitals but this relationship has not been evaluated for femoral neck fractures. The purpose of this population-based study is to determine if hospital arthroplasty volume affects patient outcomes after undergoing THA for displaced femoral neck fractures.

Methods: The Statewide Planning and Research Cooperative System (SPARCS) database from the New York State Department of Health was used to group hospitals into quartiles based on THA volume from 2000-2010. The database was then queried to identify all patients undergoing THA specifically for femoral neck fracture during this time period. The data were analyzed to investigate outcomes within high-volume and low-volume arthroplasty centers in 30-day and 1-year mortality, 1-year revision rate, and 90-day complication rate (readmission for dislocation, deep vein thrombosis, pulmonary embolism, prosthetic joint infection, or other complications related to arthroplasty in the treatment of femoral neck fractures with THA). Univariate analyses on categorical and continuous parameters were performed using chi-square and Student t tests, respectively. Time to mortality was modeled using the Kaplan-Meier method, with the log-rank test. Proportional hazard regression was used to quantify 30-day and 1-year mortality risk with THA, and 90-day complication risk based on hospital volume while adjusting for covariates that were significantly associated with mortality on univariate analysis ($P < 0.05$).

Results: The SPARCS dataset query yielded 3748 patients who underwent THA for femoral neck fracture from 2000-2010. Patients undergoing THA for femoral neck fracture at high-volume arthroplasty centers were younger (77 and 79 years; $P < 0.001$), less likely to be white (60% and 87%, $P < 0.001$), had shorter time to fixation (1.4 and 2.3 days; $P < 0.001$), and were more likely to be fixed on the day of admission or following day (66% and 51%; $P < 0.001$). The mean Charlson comorbidity index score was lower in patients undergoing THA for fracture at high-volume arthroplasty hospitals (0.7 and 0.9; $P = 0.006$). Patients undergoing THA at high-volume arthroplasty centers had significantly lower 30-day (0.9% and 5.2%; $P = 0.001$) and 1-year (7.7% and 17.3%; $P < 0.001$) mortality on univariate analysis. There was no significant difference in revision arthroplasty at 1 year and no significant differences in 90-day pulmonary embolism, deep vein thrombosis, prosthetic joint infection, dislocation, or other complication between patients undergoing THA for fracture at high-volume compared with low-volume centers.

Conclusion: The results of this population-based study indicate that THA for femoral neck fractures at high-volume arthroplasty hospitals confers lower mortality but does not influence 90-day complication rate or 1-year revision rate. When THA is performed for femoral neck fracture at high-volume arthroplasty hospitals the patients are

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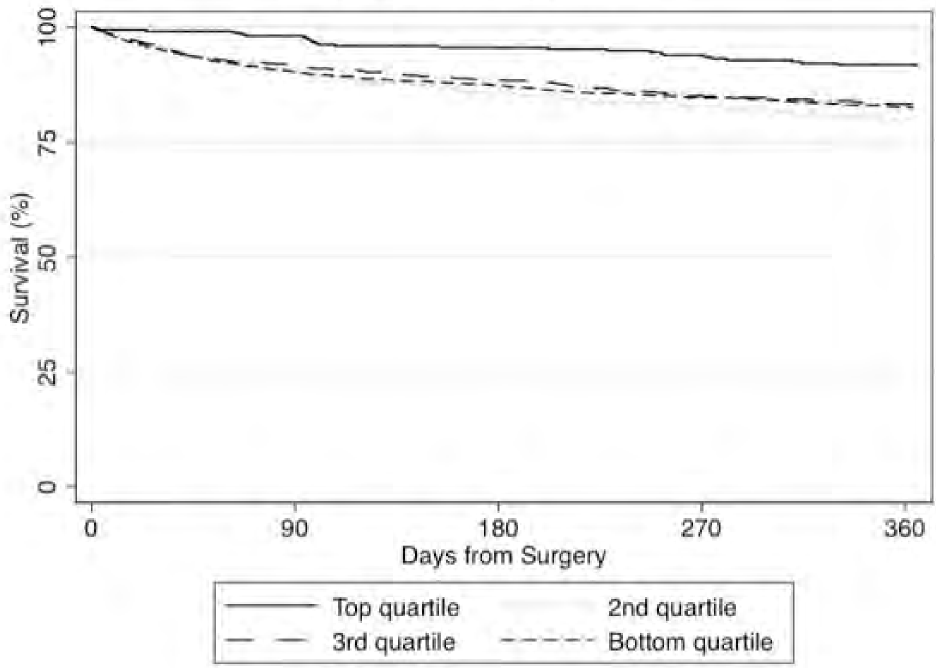
younger and healthier. The mortality benefit seen in the top quartile hospitals is more likely the result of careful patient selection rather than institution procedural experience.

Fig 1. Post Operative Survival Within Arthroplasty Volume Quartiles Following THA for Femoral Neck Fracture



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.

Does Admission to Medicine or Orthopaedics Impact a Geriatric Hip Patient's Hospital Length of Stay?

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Background/Purpose: Due to our aging population, hospitals are treating more hip fracture patients each year. As the cost of treatment for hip fractures continues to rise, hospitals must find avenues to contain costs while maintaining quality care. Given that prolonged hospital length of stay (LOS) is a major driver of cost, it has been hypothesized that admission to the medicine service as compared to orthopaedics could decrease LOS for geriatric hip fracture patients. The purpose of our study was to determine if LOS for geriatric hip fracture patients was significantly impacted by admission to the medicine service or orthopaedic service.

Methods: A retrospective cohort of all patients presenting with a low-energy geriatric hip fracture at a Level I trauma center from January 2000 to December 2009 were identified using CPT codes. Data were collected on patient demographics, medical comorbidities, length of hospitalization, and admitting service. Bivariate analyses using the chi-squared test and Wilcoxon Mann-Whitney test were performed to compare risk factors between patients admitted to the medicine or orthopaedic service. A negative binomial regression model controlling for several important patient factors, such as American Society of Anesthesiologists (ASA) score and individual patient comorbidities, were used to evaluate hospital LOS after surgery.

Results: 614 geriatric hip fracture patients were included in the analysis, of which 49.2% (n = 302) were admitted to the orthopaedic service and 50.8% (n = 312) were admitted to medicine. The average LOS for patients admitted to orthopaedics was 4.5 days compared to 7 days for patients admitted to medicine (P <0.0001) (Figure 1). As shown in Table 1, patients admitted to orthopaedics were younger in age compared to those admitted to medicine and presented with a significantly lower range of ASA scores (P <0.0001). Readmission was also significantly higher for patients admitted to medicine (n = 92, 29.8%) compared to orthopaedics (n = 70, 23.1%). After controlling for individual patient factors, it was determined that medicine patients are expected to stay about 1.5 times (IRR 1.48, P <0.0001) longer in the hospital than orthopaedic patients.

Conclusion: This is the first study to demonstrate that admission to medicine compared to orthopaedics for geriatric hip fractures increases a patient's expected LOS after controlling for confounding factors. Since LOS is a major driver of cost as well as a measure of quality care, it is important to understand the factors that lead to a longer hospital stay to better allocate hospital resources. Orthopaedic surgeons should be aware that admission to medicine increases the patient's expected length of stay.

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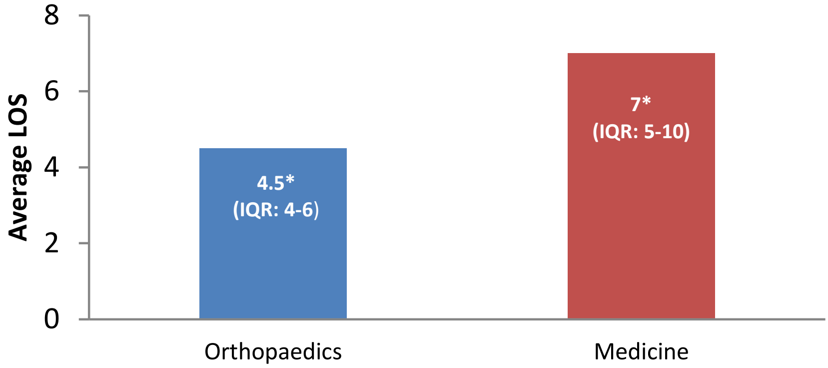
Figure 1. Average LOS for Patients Admitted to Medicine or Orthopaedics



*p<0.0001

Table 1. Characteristics for Patients Admitted to Medicine and Orthopaedics

	Orthopaedics (49.2%, N=302)	Medicine (50.8%, N=312)	p-value
Age (Mean, IQR)	77.5 (70-85)	81 (71-86.25)	<0.0001
Sex (N, %)			0.0038
Male	82 (27.2%)	120 (38.5%)	
Female	220 (72.8%)	192 (61.5%)	
ASA Score (N, %)			<0.0001
1	1 (0.3%)	0 (0.0%)	
2	44 (14.6%)	14 (4.5%)	
3	220 (72.8%)	200 (64.1%)	
4	37 (12.3%)	96 (30.8%)	
5	0 (0.0%)	2 (0.6%)	
Readmission rate	70 (23.1%)	92 (29.8%)	0.038

Cephalomedullary Nail Versus Sliding Hip Screw for Fixation of OTA 31A1/2 Intertrochanteric Femur Fractures: A 12-Year Comparison

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Background/Purpose: Intertrochanteric and pertrochanteric femur fractures are among the most common orthopaedic injuries in the elderly population, with an annual incidence of more than 145,000 in the United States. With an annual expenditure upward of $6 billion dollars in direct hospital costs and a first-year mortality of greater than 20%, outcomes after treatment of intertrochanteric femur fractures have become a major focus. The purpose of this study was to retrospectively compare failure and complications associated with cephalomedullary nail (CMN) versus sliding hip screw (SHS) fixation for intertrochanteric femur fractures at a single Level I trauma center.

Methods: Intertrochanteric femur fractures were identified in 535 patients. 333 were found to be OTA 31A1.1-3, 31A2.1-3 fracture patterns and 89 were excluded for follow-up of less than 6 months. 244 patients were included in the final analysis, 131 receiving a CMN and 113 receiving an SHS. Medical records were reviewed for demographics, surgeon training, comorbidities, complications, and subsequent hip surgery, including removal of painful implants. Radiographs were reviewed for OTA classification, reduction quality, tip-apex distance (TAD), collapse, fracture, and cutout. Failure was defined as cutout, nonunion, fracture, collapse of more than 2 cm on follow-up radiographs, or revision surgery, not including removal of symptomatic implants or treatment of underlying arthritis. Chi-square or Fisher exact tests were used to calculate P values for failure, complications, and 30-day and 1-year mortality. Adjusted P values were calculated using logistic regression or Firth logistic regression adjusting for sex, age, Lezzoni comorbidities, days since surgery, and TAD. Odds ratios were calculated for failure, complications, and 30-day and 1-year mortality. Hazard ratios were calculated for comparative overall mortality. Results were stratified by fracture type as stable (AO 31A1.1-2.1) and unstable (AO 31A2.2-3). In stable fractures CMN was more likely to be used in women and an SHS in men ($P = 0.028$), There was no difference in the unstable fracture group. TAD in stable CMN patients was 17.3 ± 5.9 compared to 26.2 ± 7.9 in the stable SHS group ($P < 0.001$) while it was 19.0 ± 5.3 in the unstable CMN group compared to 24.0 ± 6.7 in the unstable SHS patients ($P = 0.004$). In stable fracture patterns there was no difference in collapse ($P = 0.223$), complications ($P = 0.881$), failure ($P = 0.233$), or mortality ($P = 0.736$). In unstable fractures CMN had significantly less collapse ($P < 0.001$) and failure ($P = 0.46$) but no difference in complication ($P = 0.126$) or mortality ($P = 0.586$).

Conclusion: There were no significant differences in failure or complication rates when comparing the CMN to the SHS in stable intertrochanteric hip fractures while the CMN had significantly reduced failure and collapse rates in unstable intertrochanteric hip fractures.

POSTER ABSTRACTS

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Outcome	CMN	DHS	P-value	Adjusted P	Odds/Hazard ratio (95% CI) (CMN vs. DHS)
Collapse (mm)	-2.9 (6.6)[1]	8.5 (11.7)[1]	<0.01[2]	<0.01[4]	-11.05(-13.83 to -8.27) *
Complication	41 (31.3%)	43 (38.1%)	0.268[3]	0.359[5]	0.74 (0.39 -1.41)
Failure	9 (6.9%)	21 (18.6%)	0.006[3]	0.037[5]	0.355 (0.134 - 0.94)

[1]Mean (SD), [2] Wilcoxon rank sum test and T-test (same result), [3] Chi-square test, [4]Analysis of covariance adjusting for sex, age, Iezzoni comorbidities, total-tad, and days since surgery. [5] Logistic regression adjusting for sex, age, Iezzoni comorbidities, total-tad, days since surgery
*parameter estimate for nail vs. plate

POSTER ABSTRACTS

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.

Utility of Advanced Imaging in Treating Pelvic Ring Insufficiency Fractures in the Geriatric Population

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Background/Purpose: The incidence of pelvic insufficiency fractures is increasing with the aging population. Previous studies have estimated that insufficiency fractures make up nearly two-thirds of all pelvic fractures, and 94% of pelvic fractures in patients greater than 60 years old. The diagnostic evaluation of geriatric pelvic fractures can be problematic. Posterior ring injuries are frequently missed on radiographs and the use of advanced imaging (CT or MRI) to evaluate for posterior ring injuries in this cohort is controversial. Patients referred to the orthopaedic trauma service at our institution have frequently already undergone advanced imaging. This study investigates the utility of advanced imaging to evaluate the posterior pelvic ring in the setting of a pelvic insufficiency fracture. We hypothesized that advanced imaging of the pelvis, either positive or negative for posterior ring injuries, would not change the clinical management of these patients.

Methods: A retrospective review was performed on patients who sustained pelvic insufficiency fractures (OTA 61-A based on radiographs) and received treatment by orthopaedic surgeons at our institution from 2004-2014. Our inclusion criteria were age greater than 60 years and low-energy mechanism (eg, fall from standing). Patients were identified via CPT codes. Imaging was reviewed by two orthopaedic surgeons and a radiologist. Radiography and advanced imaging, if applicable, were analyzed for anterior and posterior pelvic ring injuries. Clinical notes were reviewed to determine if the patient's weight-bearing status was altered or if they were indicated for operative treatment based on the findings of advanced imaging.

Results: A total of 87 patients met our criteria. 42 patients had undergone advanced imaging to evaluate for posterior ring injuries (10 MRI, 32 CT). Table 1 shows the distribution of pelvic ring injuries in these patients. In the advanced imaging cohort, two patients had a posterior ring injury identified on radiographs alone, and an additional 24 patients had posterior ring injuries identified via advanced imaging (2 of 42 vs 26 of 42, P <0.0001). Of the posterior ring injuries, 23 were sacral impaction fractures and 3 were complete posterior ring injuries (1 complete sacral fracture and 2 crescent fractures). In the non-advanced imaging cohort, 7 of the 45 patients had posterior ring involvement noted on radiographs. Overall, 57 patients had at least 6-week follow-up and 41 patients at least 3-month follow-up. The treatment plan for all patients remained protected weight-bearing as tolerated, irrespective of advanced imaging findings. Furthermore, no patient underwent surgical intervention by final follow-up.

Conclusion: Many clinicians resort to advanced imaging to identify or further characterize posterior pelvic ring injuries to aid in determination of treatment, at a substantial cost to the health-care system and radiation to the patient. In our study, despite advanced imaging identifying additional posterior pelvic ring injuries in 57% of the advanced imaging cohort, no patient's treatment course was altered. Therefore, our data support that it may

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be unnecessary to obtain advanced imaging studies in geriatric patients that sustain pelvic insufficiency fractures identified on plain radiographs. Further study should investigate pelvic displacement and clinical outcomes in these patients.

Table 1: Summary of Radiographic Findings

Posterior Injury	Anterior Injury	Advanced Imaging (n = 42)	No Advanced Imaging (n = 45)
None	Unilateral Ramus	16 (38%)	38 (84%)
	Bilateral Rami	0	0
Incomplete	No Rami	1 (2%)	0
	Unilateral Ramus	20 (48%)	5 (11%)
	Bilateral Rami	2 (5%)	2 (5%)
Complete	Unilateral Ramus	3 (7%)	0

Helical Blade Versus Lag Screw Fixation for Cephalomedullary Nailing of Low-Energy Pertrochanteric Femur Fractures: Is There a Difference in Cutout?

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Background/Purpose: The helical blade was designed to remove less bone from the femoral head with the intention of providing stronger fixation and resistance to cutout in the femoral head. This study measured the rate of cutout of helical blades and lag screws in low-energy pertrochanteric femur fractures treated with cephalomedullary nailing.

Methods: A retrospective review was performed at two teaching hospitals of all pertrochanteric femur fractures (AO/OTA 31-A1,2,3) treated with a trochanteric entry cephalomedullary nail from January 1, 2007 through September 30, 2014. Patients who were 55 years or older, had sustained a fracture by a low-energy mechanism, and had at least 3 months of radiographic follow-up were included. Pathologic and periprosthetic fractures were excluded. Time to cutout as well as direction of cutout were recorded. Tip-apex distance (TAD) was measured on postoperative imaging. Statistical analysis was performed with the Fisher exact test and unpaired t test.

Results: Of 932 charts reviewed, 362 met inclusion criteria. The average age of the patients was 83 years and 95.9% had fallen from a standing or seated height. A majority of patients had pertrochanteric fractures that were classified as unstable (64.6%). A helical blade was utilized in 93 patients and a lag screw in 269 patients, according to surgeon preference. The average length of follow up was 11.5 months. 22 cutouts occurred, 14 with helical blades (15.05%) and 8 with lag screws (2.97%). Cutout with the helical blade was significantly more frequent than with the lag screw (P = 0.0001). There was no difference in the prevalence of unstable fractures in those patients who had cutout versus those that did not in either group. The average TAD was significantly greater for those patients who experienced cutout both for the helical blades (23.52 mm vs 19.73 mm; P = 0.0194) and lag screws (24.54 mm vs 20.02 mm; P = 0.0197) (Figures 1-3).

Conclusion: When the helical blade was utilized for proximal fixation, implant cutout occurred at a significantly higher rate compared to lag screw fixation. There was not a threshold TAD that was predictive of cutout for either implant. This suggests that the higher risk of cutout is associated with the helical blade itself and not with the surgical technique. Further investigation is warranted to determine other factors that may contribute to cutout when utilizing an intramedullary device.

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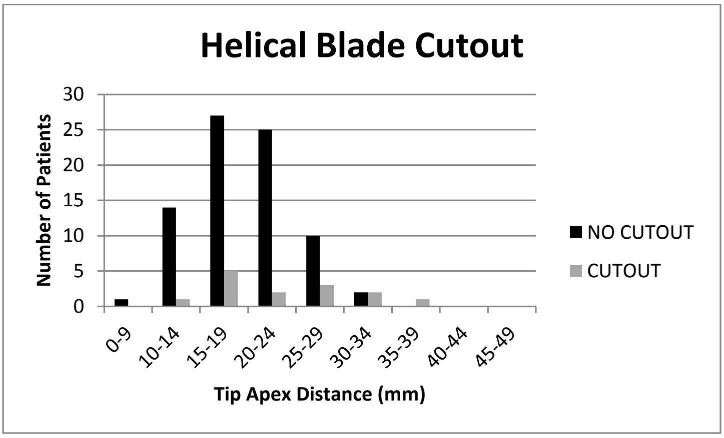

Figure 1: Helical blade cutout.

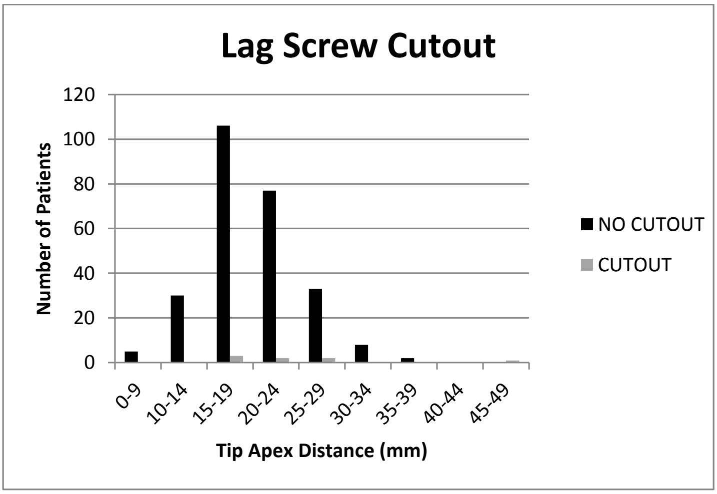

Figure 2: Lag screw cutout.

	0-9 mm	10-14 mm	15-19 mm	20-24 mm	25-29 mm	30-34 mm	35-39 mm	40-44 mm	45-49 mm
Helical Blade (n=93)	0/1	**1/15 (6.67%)**	**5/32 (15.63%)**	**2/27 (7.41%)**	**3/13 (23.08%)**	**2/4 (50%)**	**1/1 (100%)**	0/14	0/14
Lag Screw (n=269)	0/5	0/30	**3/109 (2.75%)**	**2/79 (2.53%)**	**2/35 (5.71%)**	0/8	0/2	0/0	**1/1 (100%)**

Figure 3: Percent cutout for each device by tip-apex distance.

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.

What Are the Risk Factors for a Delay of 48 Hours or More in the Surgical Management of Geriatric Hip Fractures?

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Background/Purpose: Multiple studies have demonstrated a benefit to early surgical intervention in the treatment of geriatric hip fractures. The American Academy of Orthopaedic Surgeons recently published guidelines for the treatment of hip fractures in the elderly that included a recommendation for surgery within 48 hours. Despite these data and recommendations, there are little published data on the timing of hip fracture surgery in the United States. The primary purpose of this study is to evaluate how frequently US hospitals meet the goal of performing hip fracture surgery within 48 hours of patient admission. Secondary goals are to establish if there is a correlation between patient demographic characteristics, level of care (trauma designation), or hospital region in the timing of hip fracture surgery.

Methods: The National Trauma Database (NTDB) 2012 was queried for patients over the age of 65 years who had ICD-9 procedure codes encompassing the surgical management for proximal femur fractures (78.55, 79.15, 79.35, 81.51, and 81.52). Patient characteristics including age, sex, race, insurance status, ISS, and Charlson Comorbidity Index (CCI) were obtained. Hospital characteristics including trauma designation and geographic region were collected. Outcome variables were time from admission to surgery and inpatient mortality.

Results: The overall median time from admission to surgery was 18 hours (interquartile range 5-34 hours), while 16.3% of patients had a delay to surgery of at least 48 hours from admission. Using a multivariate logistic regression analysis, independent patient factors that were associated with a significantly higher odds of a delay to treatment included: male sex, race (Black, Hispanic, other, unknown), higher CCI, and patients with a higher ISS (Table 1). Insurance status was not a risk factor for a delay in surgery. Hospitals located in the Northeast and South had higher rates of delays in surgery compared to hospitals in the Midwest and West. While there were differences in mean time to surgery, in the multivariate analysis there were only slight differences in the rate of delay in surgery based on hospital trauma designation. Patients who died during their admission were 2.3 times more likely to have had a delay in surgery compared to those who did not, controlling for all other known risk factors ($P < 0.001$).

Conclusion: Surgical management within 48 hours of admission has been associated with improved mortality in geriatric hip fracture patients. In this large cohort from the NTDB this benchmark was met 84% of the time. Independent patient risk factors for a delay of greater than 48 hours included: male sex, race, increased CCI, and increased ISS. The timing of surgery was not correlated with hospital trauma designation. This study highlights potential areas of disparity in the timing of the surgical management of hip fractures and can serve as a benchmark to assess how individual hospitals compare to national standards.

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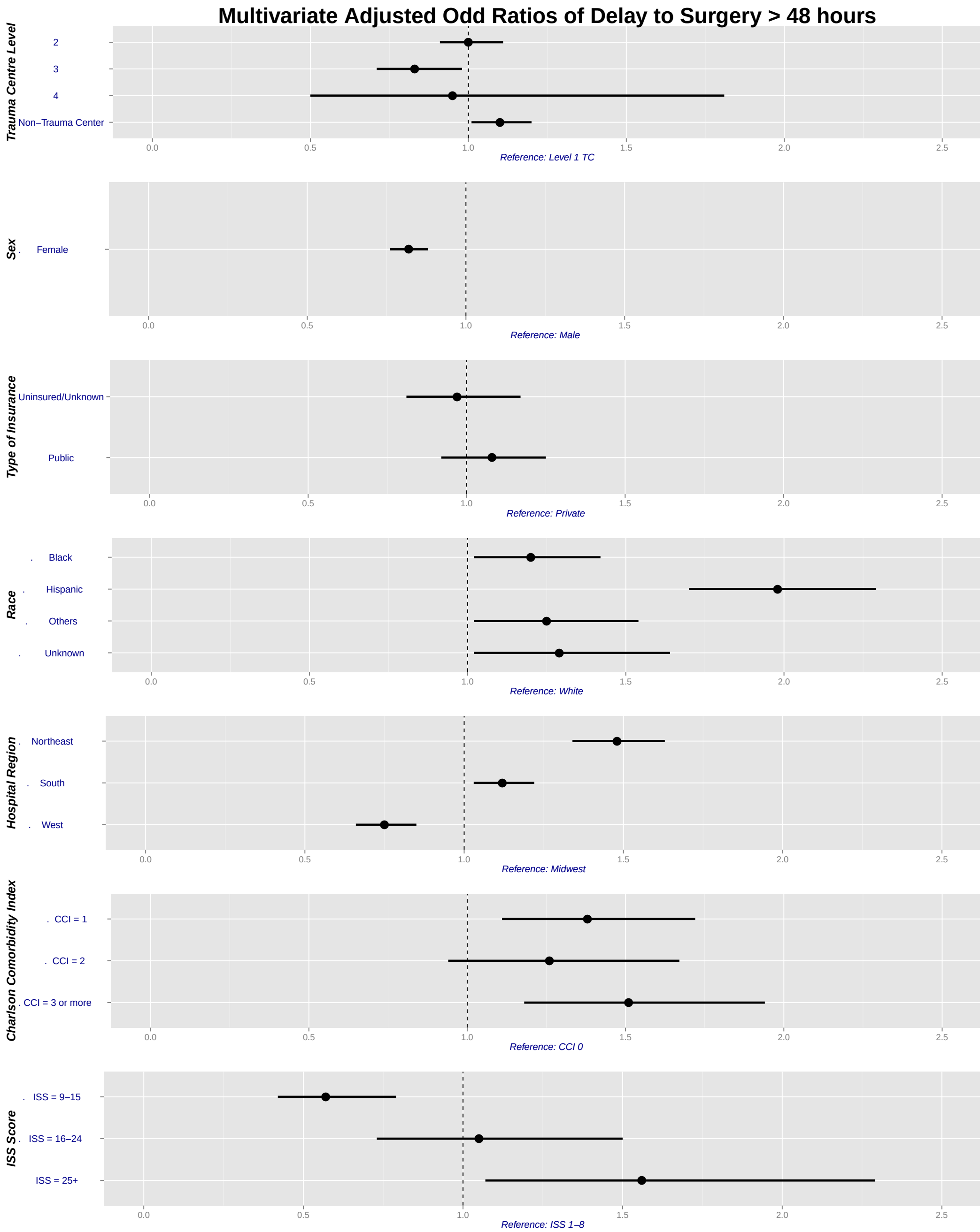

POSTER ABSTRACTS

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.

Retrospective Analysis of Distal Ulna Fractures Associated with Distal Radius Fractures in Women 50 Years and Older: Clinical, Radiographic, and Patient-Related Outcomes

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Purpose: The effect of distal ulna fracture (DUF) on outcomes of distal radius fracture (DRF) is not known. Previous studies noted trends in outcomes but did not reach statistical significance. The purpose of this analysis was to determine the incidence of DUF associated with DRF in a discrete group (women 50 years and older), to classify and describe the incidence of DUF by location, and to determine whether the presence, location, or union of DUF influences the radiographic, clinical, and patients' self-reported outcome measures in DRF treatment.

Methods: Data for 781 women 50 years and older who had sustained a displaced, isolated DRF were collected prospectively. Clinical outcomes of grip strength and range of motion (ROM) (dorsiflexion, palmar flexion, supination, and pronation), and Patient-Rated Wrist Evaluation (PRWE) scores were measured at 9, 12, 26, and 52 weeks post fracture. Radial inclination (RI), ulnar variance (UV), and radial tilt (RT) were measured up to 12 weeks post fracture from serial radiographs that were also retrospectively reviewed to determine the frequency, type, and union of associated DUFs.

Results: The rate of DUF associated with DRF was 74%. DUFs were classified by location: 19% were Type 1A (styloid apex), 39% Type 1B (styloid body), 33% Type 2T (transverse - proximal to fovea), 11% Type 2O (oblique - proximal to fovea), 0.3% Type 3 (head), and 10% Type 4 (periphyseal and distal shaft). DUF rates did not vary with age, although the type of fracture did. The DUF union rate was 35%, influenced by fracture type and age. Significant associations included: Type 1A with younger age (50-60 years), lower union rates, and a higher final RI; Type 1B with lower union rates; Type 2T with lower RI; Type 2O with older age group (81 years+), higher union rates, and lower RI; Type 4 with older age groups (81 years+), higher union rates, and higher RI; and united DUFs with significantly higher RI. PRWE scores were higher at 9 and 12 weeks post fracture in those with DUFs (not significant [NS]), higher in ununited DUFs (NS), but not at 6 and 12 months post fracture. DUFs had no effect on grip strength or ROM.

Conclusion: Rates of DUF associated with DRF were higher than those previously reported. We have classified DUFs based on location with each type and subtype having significant distinct features. The rate of DUF union was low but was more likely in older age groups and resulted in improved radiographic outcomes. The presence and type of DUF was not associated with differences in ROM or PRWE scores. Recognizing the presence of a DUF and identifying its type helps predict the behavior of not only the healing of the DUF, but also the DRF.

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Prevalence of Osteoporosis, Low and Normal Bone Density in Women Over 50 with a Distal Radius Fracture, and Their Relationship to Clinical and Radiographic Outcomes

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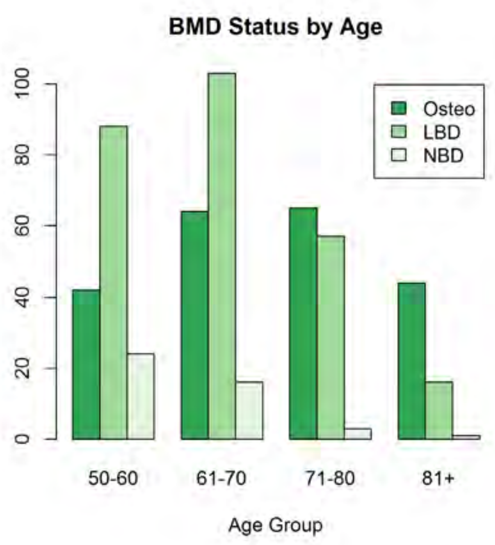
Background/Purpose: It is estimated that one in four women over 50 years of age has osteoporosis, but how can we predict whom it will affect? Given that distal radial fractures (DRFs) are one of the most common fractures sustained by adult women, the purpose of this analysis was to determine the prevalence and distribution of three bone densities (osteoporosis [OP], normal [NBD], and low [LBD]) in a cohort of women 50 years and older who had sustained a DRF, and to evaluate the role that bone density might play in eventual outcomes--radiographic, clinical, and patients' self-reported. Establishing a clear link between DRF and incidence of OP would allow for the use of DRF as an event that should prompt bone mineral density testing so that patients identified as having OP can be counseled and treated.

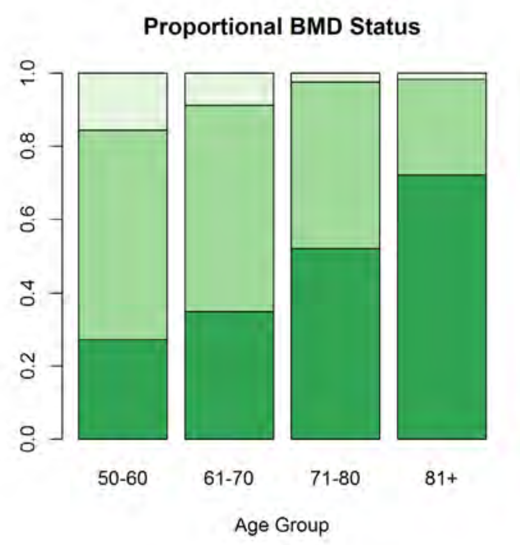
Methods: Clinical and radiographic data for 523 women 50 years and older who had sustained a DRF were collected prospectively. All 523 of these women had DXA (dual x-ray absorptiometry) scan bone mineral density tests. Clinical outcomes of grip strength and range of motion (ROM) (dorsiflexion, palmar flexion, supination, and pronation), and Patient-Rated Wrist Evaluation (PRWE) scores were measured at 9, 12, 26, and 52 weeks post fracture. Radial inclination (RI), ulnar variance (UV),and radial tilt (RT) were measured up to 12 weeks post fracture from serial radiographs. Relationships between DXA scan results and clinical and radiographic outcomes were explored for any statistically significant correlation.

Results: Overall among all patients 41.1% had OP, 50.5% had LBD, and 8.4% had NBD. In the 50-60-year age group the proportion of OP, LBD, and NBD was 27%, 57% and 16%; in the 61-70-year age group 35%, 56%, and 9%; in the 71-80-year age group 52%, 46%, and 2%; and in the 81+ group 72%, 26%, and 2%, respectively. Femoral neck T-scores more closely correlated with the bone mineral density than total hip and spine T-scores. Post closed reduction the degree of correction of RI was significantly less ($P = 0.0007$), and the final RI was lowest ($P = 0.013$) in OP patients. While initial ulnar variance did not differ significantly between bone density groups, the final ulnar positive variance was greatest ($P = 0.01$) in OP. Correction of radial (volar) tilt post reduction was lowest in the OP group ($P = 0.045$), but difference in final tilt did not reach statistical significance. Grip strength measurements of the uninjured limb were significantly less in the OP group compared to the others ($P < 0.00001$) at all measurement time points (initial visit, 9, 12, 26 and 52 weeks). Grip strengths of the injured limb in patients with OP were significantly lower at 9 ($P = 0.019$), 12 ($P < 0.00001$), 26 ($P < 0.00001$), and 52 ($P < 0.00001$) weeks post fracture. Although PRWE scores were not influenced by bone mineral density at 9 and 12 weeks post fracture, scores were significantly higher in patients with osteoporosis at both 6 months ($P = 0.01$) and 12 months ($P = 0.016$) post fracture.

Conclusion: Over 40% of all women 50 years old and older who sustained a DRF in our series had osteoporosis, with the proportion rising as age increased: the rate of OP was 27%

in the 50-60-year-old group, over 50% in the 71-80-year-old group, and almost 75% in those over 80 years old. In those patients with OP restoration of radial inclination (analogous to radial height) and volar tilt by closed reduction was least successful, and the final ulnar variance, as a measure of radial axial shortening, was greatest in OP. Grip strength measurements of both the injured and uninjured limbs in patients with OP were significantly lower at all time points. PRWE scores were significantly higher in patients with osteoporosis at both 6 and 12 months post fracture. Given these findings, a DRF in a woman 50 years or older should be considered a sentinel event. Bone density evaluation is recommended in order to discover those many women with a distal radial fracture who also have OP, so that appropriate OP treatment can be initiated.





POSTER ABSTRACTS

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Prophylactic Fixation of Contralateral Side is Cost-Effective After Bisphosphonate-Associated Atypical Femur Fracture

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Background/Purpose: Long-term bisphosphonate use can increase risks of atypical subtrochanteric fractures and contralateral involvement. At initial presentation, up to 50% of patients have contralateral radiographic changes and nearly 25% experience a complete contralateral fracture within 2 years. Surgical treatment of incomplete fractures has been found to be more safe and effective than nonoperative treatment, which has been associated with increased pain, compromised healing, and fracture completion with displacement. Thus, this study was undertaken to assess the cost-effectiveness of contralateral prophylactic fixation after unilateral bisphosphonate-associated fracture. We hypothesized that it would be cost-effective to prophylactically fix the contralateral femur when the patient is less than 75 years old or, has symptoms or radiographic findings such as radiolucent fracture line suggesting impending fracture.

Methods: A Markov cost-effectiveness model was created based on patient age at time of fracture (60-90 years), and presence or absence of risk factors (pain, radiographic findings). Sensitivity analysis was performed on outcome probabilities, costs, and utilities in the form of quality-adjusted life years (QALYs), which were determined using orthopaedic literature and expert opinion. QALYs were assumed to decrease by 10% for each year of prodromal pain, 5% for displaced fracture, 30% for displaced fracture with complications, and 10% for prophylaxis with complications. Actuarial death rates were doubled during the year of prophylactic surgery and 5x the year of displaced fracture surgery. QALYs and costs were discounted at an annual rate of 3%. Incremental cost-effectiveness ratios (ICERs) were calculated by dividing extra costs by gains in QALYs. ICER <$50,000/QALY was interpreted as cost-effective, $50,000-$100,000 or QALYs lost as not cost-effective.

Results: Contralateral fracture risk over 5 years was valued at 25% with no risk factors, 45% with 1 risk factor, and 61% with 2 risk factors. Displaced fracture surgery was estimated at $36,200, with an extra $10,000 from complications, which was approximated at 40%. Prophylaxis was estimated at $16,600, with an extra $1000 from complications, approximated rate at 20%. Sensitivity analysis demonstrated cost-effectiveness of prophylaxis at any age with risk factors (pain or radiographic findings). Without risk factors, prophylaxis was possibly cost-effective for ages 60-78 years but not cost-effective if 79 and older.

Conclusion: This is the first sensitivity analysis study that supports contralateral prophylactic fixation in the setting of younger age and pain or radiographic changes. Surgeons and patients with atypical bisphosphonate-associated femur fractures must decide between observation and contralateral prophylactic fixation. The principal advantage of observation is avoiding the morbidity and cost of prophylactic surgery. The advantages of prophylaxis are the high likelihood of successful surgery and the avoidance of a displaced fracture. Prophylaxis was possibly cost-effective in some patients without symptoms or radiographic findings, suggesting that other factors may need to be incorporated to guide treatment. In the absence of large prospective or randomized studies, decision and cost-effectiveness analysis are excellent techniques to study effects of various treatment strategies. Further research is indicated to prospectively study the efficacy of prophylactic surgery versus observation in this patient population.

Retrospective Review of Completed Displaced Femoral Neck Stress Fractures in Young Adults

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Background/Purpose: Completed displaced femoral neck stress fractures (FNSFs) are a rare injury most commonly seen in military personnel and elite athletes. These AO/OTA 31-B2.1 and 31-B2.2 fractures may develop nonunion or osteonecrosis (ON) as a result of injury. The optimal reduction technique and implant is controversial. Furthermore, the long-term prognosis of this injury and need for total hip arthoplasty (THA) is unknown with urgent contemporary surgical techniques. The purpose of this study was to review the results and complications associated with the treatment of completed displaced FNSFs.

Methods: After IRB approval, the operating room surgical database was utilized to obtain all patients undergoing operative treatment for stress fracture of the proximal femur. Incomplete and nondisplaced FNSFs were excluded. Patient demographic information was recorded. A comprehensive review of the electronic medical record was then completed. All available imaging was reviewed and measurements were recorded. Metabolic/endocrine abnormalities, previous stress fractures, prodromal symptoms, and primary care diagnoses prior to completion were noted. Method of reduction and type of implant were assessed. Primary outcomes of nonunion, ON, conversion to THA, and return to active duty were recorded.

Results: 27 completed displaced FNSFs were identified from 2001 to 2015. Marine recruits were the largest population at risk. Running was the most common mechanism of completion. Average age at time of injury was 23.4 years. Prodromal symptoms were noted by primary care providers in 81.4% of patients. 25 underwent urgent reduction, two were delayed. Open reduction was performed in 11 patients (40.7%), while 16 (59.3%) underwent closed reduction. Nine patients (33.3%) developed a nonunion. Nonunion was seen most commonly after multiple cancellous screw fixation. Five nonunions were treated with an intertrochanteric osteotomy; three (40%) successfully united the nonunion. ON developed in six fractures (22.2%), which required conversion to THA in all six patients at an average age of 26.8 years. No femoral head-preserving procedures were performed. After union, 40% of active duty personnel were able to return to duty.

Conclusion: The results of this study highlight the importance of prompt diagnosis of incomplete FNSFs given the potentially disastrous outcome of completed displaced FNSFs. We found Marine recruits to be the highest at-risk population. High rates of nonunion and ON were seen in our series despite urgent contemporary surgical techniques. After union, however, patients can continue on active duty. To our knowledge, this study represents the largest series of completed displaced FNSFs undergoing urgent surgical management using contemporary techniques.

Outcome of Periprosthetic Femoral Fractures with Retained Total Hip Arthroplasty Treated with a Polyaxial Locking Plate

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Background/Purpose: According to the American Academy of Orthopaedic Surgeons, more than 193,000 total hip arthroplasties (THAs) are performed each year in the US. Femoral fractures are not common, but occur in 0.1% to 6% of all patients who have THA. Therefore, approximately 10,000 periprosthetic femur fractures need treatment annually with the majority (75%) occuring at the tip of the stem (Vancouver type B1). Most recently, plates that allow screw angling around the implant shaft have been introduced. The purpose of this study was to evaluate a series of periprosthetic femoral fractures after THA treated with polyaxial locking plate regarding outcome and complications.

Methods: Over a 9-year period, 2005-2014, 83 consecutive periprosthetic femoral fractures (AO/OTA 32) following THA from one academic trauma center were retrospectively identified as having been treated with polyaxial locked plate fixation (NCB, Zimmer). Of these, 61 fractures in 61 patients (70.5% female) met the inclusion criteria. 22 patients (26.5%) were excluded due to follow-up less than 6 months. Patient age was 77 years (range, 44-94 years) and BMI averaged 26.9 kg/m2 (18.4-44.1 kg/m2). 21 patients (34.4%) previously had a revision THA. In addition, 19 patients had an interprosthetic fracture with additional total knee replacement. Fixation constructs for plate and working length were delineated. Demographics were assessed. Nonunion, infection, and implant failure were used as complication variables.

Results: All patients were treated operatively. 48 fractures (78.7%) healed after the index procedure. 13 of 61 (21.3%) required additional surgeries related to infection (5) 8.2 %, nonunion (7) 11.5 %, hardware failure (5) 2.0%, and 1 patient with plate removal due to symptomatic hardware (1.6%). Additional surgeries were performed after 259 days (range, 14-701 days). Hospital stay averaged 19.9 days. Operative time was 122.4 minutes. For technical aspects, 36 patients (59%) were treated with distal femur plates (NCB-DF), 25 patients (41%) were treated with periprosthetic plates (NCB-PP). The utilized plate length averaged 303 mm (range, 167-373 mm). Working length was 0-197 mm (mean 56.4 mm). Working length was significantly shorter in patients with nonunion formation (38 mm vs 59 mm, P = 0.019). Interprosthetic fractures did not lead to an increase in nonunion formation or hardware failure (P = 0.477, P = 0.574, respectively). Patients with previous revision THA underwent additional surgeries in 38.1% with a significantly greater risk for infection (23.8%; P = 0.001).

Conclusion: Modern periprosthetic plates offer a wide variety of fixation techniques. Polyaxial locking plates allow for screw angling around intramedullary implants and lead to reliable union rates (88.5%), but technical aspects need to be considered. Forming a stiff construct with a short working length resulted in an significant increase in nonunion formation. Additionally, previous revision THA led to a significantly greater risk for infections and redone surgeries.

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Extracapsular Proximal Femoral Fractures (OTA/AO 31-A) in Young Adults Have Surprisingly Poor Outcomes

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Background/Purpose: Proximal femoral fractures in adults under 50 years are not as common as in the elderly population, but may have just as significant an impact. In this age group, the majority of fractures are extracapsular and are due to high-energy trauma. Our aim was to assess the outcome of operative management of extracapsular proximal femoral fractures (OTA / AO 31-A) in the young adult (<50 years).

Methods: Consecutive skeletally mature patients 50 years or younger presenting to our institution requiring operative management of extracapsular proximal femoral fractures during the period August 1999- August 2011 were obtained from a prospective database. Outcome scores were obtained via postal questionnaires. Demographic and mortality data for patients older than 50 years undergoing fixation for the same fracture types in the same period were also obtained and analyszd for comparison.

Results: For the under-50-years-old group, a total of 88 patients were included with a mean age of 38.5 years (range, 17-50). There were 3939 patients over 50 years treated for these fractures in the same time period. In the younger group, a majority of these patients were males (73.8%) and were involved in high-velocity injuries (road traffic accident or fall from a height) in comparison to the older group where there was a female preponderance (74.8%) and the main cause was a fall (81%). 43.1% of patients in the younger group had no comorbidities compared to 29.1% of the older group. In both groups the majority had pertrochanteric fractures but in the older group there was a higher prevalence of more comminuted (3- and 4-part) fractures. Most fractures in the both groups were treated with a dynamic hip screw (84.1% and 77.6%). The mean hospital stay was 13.5 days (range, 2-94) for the under-50-years-old group and 21.2 days (range, 1-169) for the older group. One-year mortality for the under-50-years-old group was 4.5% and for the over-50-years group was 33.3%. 17 (19.3%) patients in the under-50 group had died at a mean of 40 months from their operation date. All deaths resulted from other injuries or comorbidities. The complication rate in the younger group was 5.7% and in the older group 25.7%. Outcome scores (<50 years group): Most patients had returned to near-normal function as assessed by Short Form (SF)-36 and EuroQol EQ-5D but 5-10% had severe problems and there was overall an almost 20% decrease in quality of life compared to population norms with the biggest differences in the physical function modalities. One third of patients had fair to poor hip function as assessed by the Oxford Hip Score.

Conclusion: Young patients sustaining extracapsular hip fractures have a significant mortality and length of hospital stay reflecting a higher energy of injury than in older patients rather than frailty. These injuries are rare and complex due to associated injuries. Although overall functional recovery is reasonable, a significant percentage do have problems especially in the physical modalities and hip-specific function.

Intraoperative Fluoroscopy Underestimates Malreduction of Displaced Femoral Neck Fractures

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Purpose: Clinical outcomes after internal fixation of displaced femoral neck fractures are affected by reduction quality. The reduction quality is traditionally measured by tangential radiographic views to detect displacement and angulation. This concept is routinely applied intraoperatively using fluoroscopy to assess reductions; however, its accuracy has never been investigated. We hypothesize that intraoperative fluoroscopy underestimates the displacement following reduction and internal fixation of displaced femoral neck fractures.

Methods: After IRB approval, a retrospective review at our institution revealed 119 patients treated for displaced femoral neck fractures (AO/OTA 31B2 or B3) with internal fixation between 2004 and 2014. 15 patients were found to have high-quality postoperative CT scans that allowed accurate comparison measurements. Displacement was measured on fluoroscopy using the known core diameter of the implant as a reference. Displacement on CT was measured using our institutional PACS (picture archiving and communication system) measuring tools. Fracture displacement was defined as the maximal measured displacement on any view. Absolute differences in CT and fluoroscopy measurements were compared using Student t test (significance $P = 0.05$) and Pearson correlation coefficient (r). Blinded reviewers, consisting of three fellowship-trained attending traumatologists and two current trauma fellows, graded the fluoroscopic reductions as excellent (<2 mm displacement), good (2-5 mm), fair (>5-10 mm), or poor (>10 mm). This evaluation method simulated the operating room experience in that no formal measurement tools were provided. Interclass correlation coefficients (ICCs) for reliability were calculated and a linear model with a random effect for reviewer was used to quantify the difference between these categorical assessments of fluoroscopy images and corresponding CT measurements.

Results: 73% of patients were treated with open reductions. The mean absolute difference of displacement measured by fluoroscopy versus CT was statistically significant at 1.4 mm ($P = 0.001$). The correlation between the two measurements was only moderately good ($r = 0.51$, Figure 1). There was no difference in the correlation of fluoroscopy to CT measurements when subgrouping by implant ($P = 0.96$) or reduction method (1.1 mm open, 2.0 mm closed, $P = 0.325$). The ICCs of intraobserver (0.57) and interobserver (0.49) qualitative assessments were fair. Reviewer grading of fluoroscopic imaging was significantly biased to underestimate maximal displacement measured on CT ($P = 0.01$). Patients with postoperative CT scans measuring 5-10 mm of displacement were graded appropriately as "fair" only 22% of the time (58% "good" and 20% "excellent").

Conclusion: Our study shows that fluoroscopic measurements of reduced femoral neck fractures underestimate the actual displacement detected on postoperative CT scans. We found a trend towards improved correlation of measurements with open reductions. Furthermore, qualitative grading of reductions based on intraoperative fluoroscopy significantly minimizes displacement. Our study indicates that more accurate measurement of displacement may better define what constitutes a clinically significant malreduction of a femoral neck fracture.

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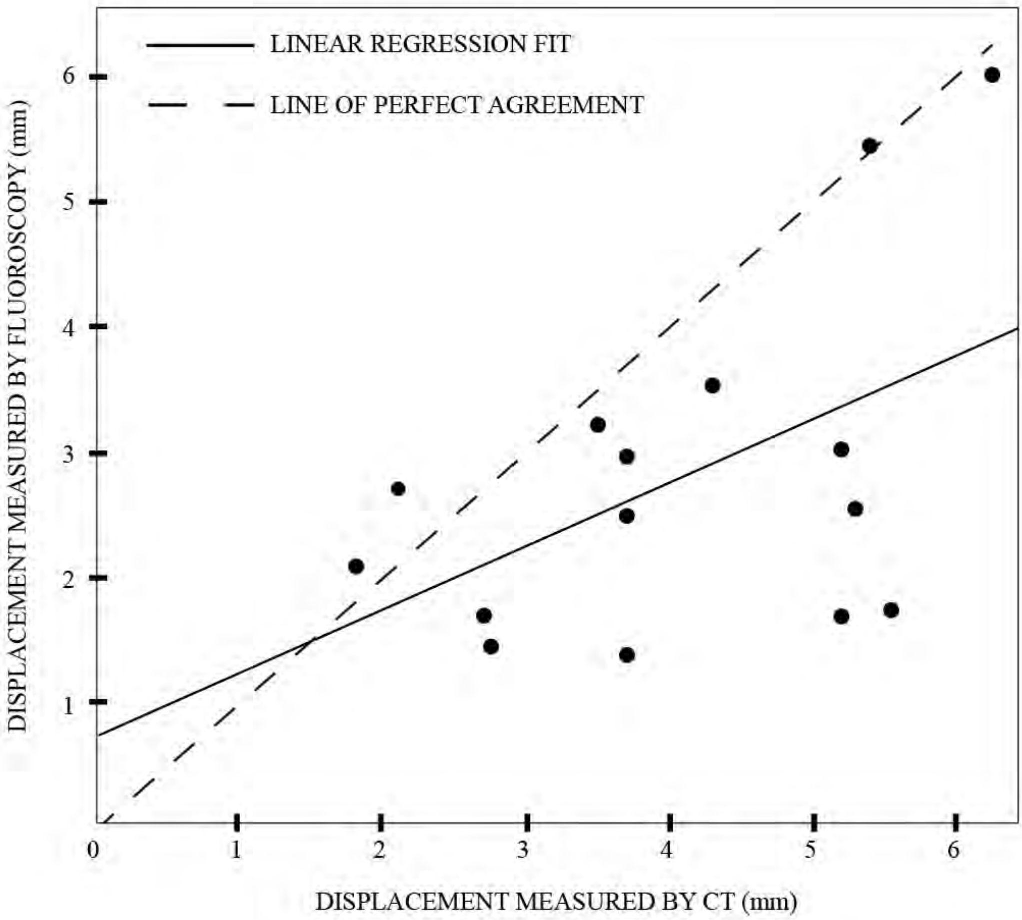

Figure 1. Scatterplot of measured displacement by postoperative CT scans and final intraoperative fluoroscopy images, showing only moderately good correlation (r = 0.51) between the modalities. As compared to the line of perfect agreement, fluoroscopic measurement underestimate the maximal displacement seen on CT scans (p = 0.001).

Safety of Osseointegrated Prosthesis for Transfemoral Amputees

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Background/Purpose: Although osseointegration has been demonstrated to improve walking ability and prosthesis-related quality of life in patients with transfemoral amputations suffering from socket-related complications, the risk of potential infectious complications has limited wider introduction to date. We report on the incidence of infection in the first 2 years after implantation and investigate potential risk factors.

Methods: Two university hospitals conducted a prospective cohort study to analyze all consecutive subjects with transfemoral amputation who underwent implantation of osseointegrated femoral prosthesis between 2011 and 2013. Infections were prospectively reported and classified using a standardized protocol (Table). Patient and clinical characteristics (gender, age, time since amputation, cause of amputation, and comorbidities including BMI [body mass index], smoking behavior and length of stoma) were recorded and relative risk (RR) and 95% confidence intervals (95% CIs) calculated to identify potential risk factors.

Results: Of 89 procedures in 84 patients (5 bilateral) performed, a total of 45 infections in 31 (34%) procedures in 29 (35%) patients were reported at median follow-up of 28 months (range, 12-65). In group A 21 Infections were classified as: 15 grade 1A, 5 grade 1C, and 1 grade 3C. Group B comprised 24 infections: 15 grade 1A. 8 grade 1C, one grade 2C. Overall, 13 (14%) of procedures in 13 patients had grade 1B-C infection. 3 of 6 (50%) smokers and 10 of 23 (43%) of women had at least one infection (RR 1.5, 95% CI 0.6-3.5; RR 1.4, 95% CI 0.8-2.5, respectively).

Conclusion: One-third of patients had at least one diagnosis of infection. The majority of infections (30, 65%) were mild, classified as superficial and managed with oral antibiotics. Infections occur but not serious, only 1% results in implant failure. Further research is required to identify risk factors to determine appropriate patient selection criteria and optimal infection prevention strategies to reduce the complication rate.

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Symptoms	Grade	Action
Soft Tissue infection		
Cellulitis with signs of Inflammation (Redness, Swelling, Warmth, Stinging Pain, Pain which increase on Loading, Tense	1A	Oral antibiotics
	1B	Parenteral antibiotics
	1C	Surgical intervention
Osteitis		
X Ray (Periosteal Bone Reaction +/- evidence of Osteitis - Sequestrum and Involucrum)	2A	Oral antibiotics
	2B	Parenteral antibiotics
	2C	Surgical intervention
Implant failure/osteomyelitis		
X Ray (Loosening)	3A	Oral antibiotics
	3B	Parenteral antibiotics
	3C	Surgical intervention

Return to Duty in Military Members Following Surgical Treatment of Incomplete Femoral Neck Fractures

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Background/Purpose: Femoral neck stress fractures (FNSFs) are a devastating injury in young adults. The incidence is highest among military members. Completion of an FNSF is a catastrophic event with complications of osteonecrosis and osteoarthritis. Surgical management is controversial but can hasten recovery and prevent progression to a completed FNSF. Prognosis after surgical fixation of incomplete FNSF is unclear due to the rarity of operative management. Long-term functional outcomes following surgical fixation of this injury are not known. Previous studies have suggested a correlation with FNSF and radiographic signs of femoracetabular impingement (FAI). The purpose of this study was primarily to retrospectively review return to active duty in patients undergoing surgical fixation for incomplete FNSFs. Secondary purpose was to identify and define the presence of radiographic indicators of FAI.

Methods: Following IRB approval, we conducted a retrospective review of the electronic medical record at our military institution. A cohort of 53 patients met inclusion criteria of active-duty men and women, ages 18-40 years, with incomplete FNSF from a nontraumatic mechanism. Descriptive statistical methods were used to determine the rate of return to duty (RTD) compared to sex, branch of service, side of fracture, and signs of FAI. Femoral neck shaft angle (FSA), center-edge angle (CEA), and femoral neck offset were measured on standard radiographs on fractured and unfractured sides by all authors and compared to RTD using two-sample t test. Inter-rater variance was calculated between authors to determine accuracy of measurements using Scheffé pair-wise comparison of means. The presence of crossover signs (COS), prominence of ischial spines (PRIS), cam lesions, and synovial herniation pits were assessed in relationship to functional outcomes.

Results: 67% of our sample population did not return to duty. Based on branch of service, 83% of Marine Corps members did not return to duty, whereas 82% of Navy active duty did return to duty, which was statistically significant ($P < 0.001$). Follow-up ranged from 2-111 months with an average of 25 months. There were 50 male patients and 3 female patients. 34 patients had right-sided fractures and 19 had left-sided fractures. The mean age at date of surgery was 21 years. RTD rates compared to sex was statistically significant ($P = 0.031$) with 3/3 (100%) female active duty members returning to duty. COS was present in 56% of patients. PRIS was present in 48%. Herniation pits were present in 15/53 (28%), while 32/53 patients (60%) had cam lesions. Prevalence of COS, PRIS, herniation pits, and cam lesions compared to RTD rates were not statistically significant but were present in the majority of those who did not return to duty. Measurements of FSA, CEA, and offset compared to RTD were not significant; however, higher offset on fractured versus unfractured sides was significant ($P = 0.014$). Analysis of variance regarding radiographic measurements revealed agreement increased with level of training.

Conclusion: Surgical fixation of FNSF does not improve a service member's ability to return to unrestricted active duty but did prevent progression to completion and displacement.

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Despite robust postoperative rehabilitation, the demands on the active-duty member in training may exceed the nature of the injury. The majority not returning to active duty were Marines in recruit basic training, whereas, the majority of those returning to duty were in Naval Special Warfare training. Self-efficacy likely plays a strong role in determining which service members will return to full duty with higher RTD rates seen in those enlisted in Special Warfare training. Counseling of service members with FNSF should reflect the severe nature of this injury and guarded prognosis for return to previous activity level. Signs of FAI were present in the majority of patients and correlated with decreased RTD but were not statistically significant. It is unclear if a causal relationship exists between FAI and FNSF. The presence of radiologic signs of FAI in this select population is higher than that reported in the literature for a normal population.

The Trochanteric Fixation Nail and Axial Migration: Tip-Apex Distance Revisited

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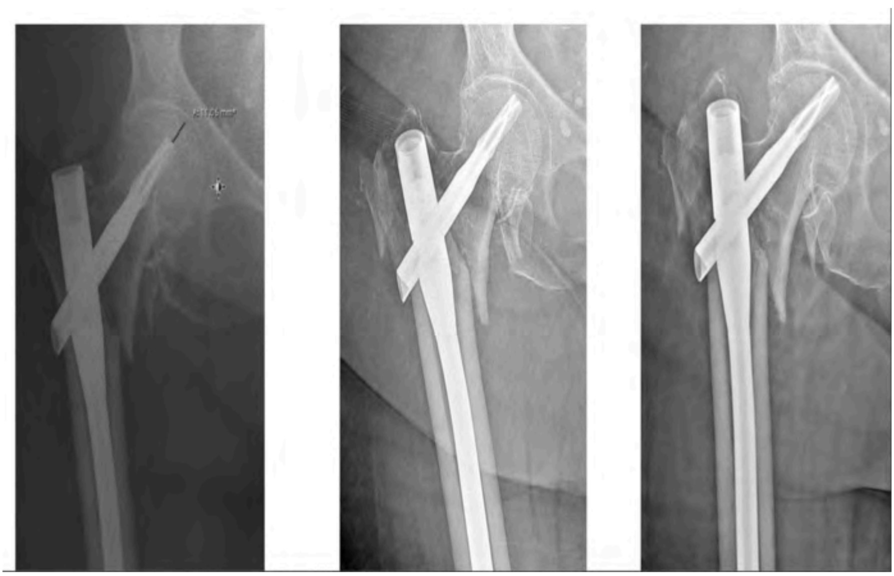
Background/Purpose: Axial migration and eventual cut-out of a helical blade within the femoral head is a unique and rarely discussed mechanical complication seen with the trochanteric fixation nail system (TFN) in the treatment of proximal femur fractures. The use of the tip-apex distance (TAD) has previously been studied as a means to predict varus collapse and eventual cut-out in systems utilizing a lag screw design. The significance of theTAD in predicting axial migration and eventual femoral head perforation for helical blade designs has been brought into question by recent studies suggesting the need for further evaluation of this parameter in predicting helical blade cut-out.

Methods: A retrospective review of 455 proximal femur fractures treated with the TFN system from 2009 to 2013 at a single institution was conducted. Fractures were classified from plain films using the AO/OTA classification; postoperative films were rated on quality of fracture reduction, TAD (mm), Cleveland zone, and data were then analyzed for axial blade migration and cut-out in the femoral head, lateral migration, and peri-implant fracture.

Results: 324 patients met inclusion criteria. The mean follow-up was 4.5 months. The overall rate of mechanical complication was 15.7%. 16 patients (4.9%) had axial blade migration in the femoral head, 31 patients (9.6%) had lateral migration of the helical blade (10 mm), and 1 patient (0.3%) had peri-implant fracture. TAD less than 20 mm was a significant predicator of blade migration in the femoral head (P = 0.01). As compared to TAD of 20 to 30 mm, implants with TAD less than 20 mm had an odds ratio (OR) = 1.47 (P = 0.009) for medial migration.



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Conclusion: Axial migration of the helical blade within the femoral head is a recognized complication of the TFN that can lead to medial perforation of the femoral head. This complication is seen more frequently than the varus collapse and superior cut-out associated with lag screw designs. Traditionally, a TAD less than 25 mm has been suggested to lower rates of cut-out with lag screw designs; however, helical blades have higher rates of medial migration associated with a TAD less than 20 mm. Placement of a helical blade with a TAD of 20-30 mm may decrease the rates of axial migration and cut-out.

Impact of Increasing Fracture Comminution and Severity on Achieving Optimal Femoral Version: An Analysis of 307 Intramedullary Femoral Nails

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Purpose: Intramedullary (IM) nailing for femoral shaft fractures has become standard of care. Complications include malrotation and malalignment, and degree of comminution and severity of injury has the potential to adversely affect proper alignment and version following IM nailing. The objective of this study was to analyze the impact of increasing injury severity and comminution and the ability to obtain proper version following IM nailing of femoral shaft fractures.

Methods: 417 consecutive patients with femur fractures were treated with an IM nail at a Level I trauma and tertiary referral center. Of these, 307 with CT scanograms with the ability to calculate femoral version were included in this study. Univariate and multivariate regression statistical models were utilized to identify any predictors of malrotation in regards to AO/OTA and/or Winquist classification.

Results: Fractures were classified by an orthopaedic trauma fellowship-trained attending surgeon. AO type A fractures were the most common (51.5%), followed by type B (30.0%) and type C (18.5%). When categorized according to the Winquist system, 49.5% were type 1, 14.7% were type 2, 21.2% were type 3, and 14.7% were type 4. In univariate analysis, none of the classification systems were predictive of postoperative distal femoral version. Subsequently, multivariate models did not yield any significant predictors.

Conclusion: Increasing degree of comminution and injury severity had no significant impact on obtaining acceptable femoral version following IM nailing. Controlling for several factors via univariate and multivariate models yielded similar results.

See pages 47 - 108 for financial disclosure information.

Fewer Complications Performing Total Hip Arthroplasty Through a Direct Anterior Approach for Femoral Neck Fracture

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Background/Purpose: There is growing evidence that active, elderly patients with a displaced femoral neck fracture should be treated with a total hip arthroplasty (THA). In this patient population, THA has led to better patient outcomes and fewer reoperations as compared to open reduction and internal fixation and hip hemiarthroplasty. However, multiple studies have demonstrated higher dislocation rates in THA for treatment of hip fracture. THA for primary osteoarthritis and hip hemiarthroplasty for fracture performed through a direct anterior approach has been associated with lower rates of dislocation. There are no studies comparing patient outcomes based on approach for THA in the setting of hip fracture. The purpose of this study was to compare patient outcomes and complications relative to surgical approach. Our null hypothesis is that there would be no difference in patient outcomes and complications between patients undergoing THA for hip fracture using a direct anterior approach as compared to a posterior approach.

Methods: Following IRB approval, we retrospectively reviewed patients who presented to our Level I trauma center with an acute, displaced femoral neck fracture from 2004-2014. Patients were excluded if they had less than 6 months of follow-up. Demographic data including age, sex, mechanism, and comorbidities were recorded. Surgical approach, arthroplasty components, and intraoperative complications were reviewed. Patient outcome data including mortality, infection, dislocation, hematoma, venous thromboembolism (VTE), and secondary surgeries were recorded. Deep infection was defined as any infection deep to the fascial layer. All patients received 4 weeks of VTE prophylaxis, and all patients initiated weight bearing on the first postoperative day.

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Results: Between 2004-2014, 88 patients with displaced femoral neck fracture were treated with THA. 32 patients were excluded for less than 6 months follow-up. The remaining 56 patients had a mean follow-up of 19 months (range, 6-91 months). The most common injury mechanism was ground level fall (77%), followed by fall from height (15%) and skiing (8%). 30-day and 1-year mortality for the entire patient cohort was 4.5% (4/88) and 12.5% (11/88), respectively. There were 35 patients in the direct anterior approach cohort with a mean age of 70 years (range, 30-92 years) and 55% were female. There were 21 patients in the posterior approach cohort with a mean age of 72 years (range, 46-84) and 71% were female. The overall complication rate was significantly higher in patients receiving a posterior approach (48%) as compared to patients in the anterior approach cohort (17%; P = 0.03). The overall postoperative infection rate was 7%, and the deep infection rate was 2%. There were significantly more postoperative infections in the posterior approach group (19% vs 0%, P = 0.016). There were more dislocations in the posterior approach cohort (10%) as compared to the direct anterior cohort (3%), but this failed to reach significance (P = 0.55). Additionally, there was a trend toward more postoperative hematomas (2 vs 0, P = 0.14) and VTEs (3 vs 2, P = 0.35) in the posterior approach group, but these failed to reach significance.

Conclusion: 30-day (4.5%) and 1-year (12.5%) mortality following hip arthroplasty for femoral neck fracture remains higher than the mortality following arthroplasty for primary osteoarthritis. The overall rates of deep infection (2%), symptomatic VTE (9%), and dislocation (5%) were higher than what has been previously reported for patients undergoing THA for primary osteoarthritis. There were significantly more postoperative complications and infections in the patients who underwent THA for displaced femoral neck fracture through a posterior approach as compared to an anterior approach. As THA for displaced femoral neck fracture becomes more common, performing the procedure through a direct anterior approach may decrease postoperative complications.

Impact of Surrounding Canal Size on Union Following Limited Reamed Intramedullary Nailing of Femur Fractures

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Background/Purpose: Diaphyseal femur fractures (AO/OTA 32A-C) are most often treated with reamed intramedullary nailing. High union and relatively low complication rates exist for such a treatment method. When choosing an intramedullary implant for a femoral shaft fracture, size of the implant selected is typically based on canal diameter, amount of reaming performed, age and sex of the patient, or surgeon preference. Our group hypothesized that the use of 10-mm intramedullary nail independent of patient demographics, fracture characteristics, intramedullary canal size at the isthmus, and amount of reaming does not alter the union rate and time to union.

Methods: 67 patients with an average of 12 months follow-up who were treated with size 10-mm intramedullary nail for a femoral shaft fracture were assessed for fracture characteristics, time to union, and union rate. Three distinct groups were compared based on difference between the intramedullary nail diameter and the size of the canal at the isthmus: <1 mm, 1 to 2 mm, and >2 mm.

Results: Baseline and demographic comparisons yielded no significant differences between the three groups in regards to mean age, gender, body mass index (BMI), mechanism of injury, or percent open injury (Table 1). There were no significant differences between the three groups in regards to AO/OTA classification (Table 2). No significant difference was found between groups when comparing mean canal diameter, mean difference between canal diameter and canal fill, and time (measured in days) to union (Table 3). We had an overall union rate of 98.5% with no mechanical implant failures.

Conclusion: Our group maintains that limited reaming technique and insertion of a 10-mm nail, independent of canal size, does not impact overall union or time to union for femoral shaft fractures. Due to the results of our study, we have implemented routine use of a 10-mm nail inserted via limited reaming technique no matter how large the canal diameter.

Table 1. Baseline and demographic information for all three comparative cohorts (total n= 67)

	Group 1 (≤1mm, >90% Fill) n=17	**Group 2 (>1 to <2mm, 90-83% Fill) n=32**	**Group 3 (≥2mm, <83% Fill) n=18**	**P Value**
Age (SD), yrs	30.8 (11.6)	30.9 (16.1)	30.1 (11.5)	0.98
Gender (%M)	71%	69%	83%	0.52
BMI	26.5 (4.2)	25.9 (3.6)	27.2 (4.7)	0.55
Ethnicity (n)				0.60
White	5	10	3	
African American	8	13	10	
Hispanic/Latino	4	8	3	
Asian	0	0	0	
Other	0	1	2	
Mechanism of Injury (n)				0.67
MVA	7	12	7	
Fall	2	2	3	
Pedestrian Struck	3	6	2	
Crush	1	0	1	
GSW	2	3	4	
Motorcycle	2	7	2	
Sports related	0	2	0	
Open Injury (n)	3	3	4	0.44

Table 2. AO/OTA 32A-C and Winquist classifications for all three cohorts (n= 67)

	Group 1 (≤1mm) n=17	**Group 2 (>1 to <2mm) n=32**	**Group 3 (≥2mm) n=18**	**P value***
AO/OTA 32				
A1	0	3 (9%)	1 (6%)	0.30
A2	5 (29%)	8 (25%)	1 (6%)	
A3	6 (35%)	10 (31%)	3 (17%)	
B1	2 (12%)	3 (9%)	2 (11%)	
B2	1 (6%)	3 (9%)	5 (28%)	
B3	0 (0%)	1 (3%)	0	
C1	2 (12%)	0	4 (22%)	
C2	1 (6%)	2 (6%)	1 (6%)	
C3	0	2 (6%)	1 (6%)	
Winquist				
1	10 (58%)	21 (66%)	3 (17%)	0.12
2	3 (18%)	4 (13%)	5 (28%)	
3	3 (18%)	4 (13%)	5 (28%)	
4	1 (6%)	3 (9%)	5 (28%)	

***Categorical comparisons via chi-squared analysis, significance p<0.05**

Table 3. Mean canal diameter, differences between the 10-mm nail and canal, and mean time to union in each study cohort (n=67).

	Group 1 (≤1mm, >90% Fill) n=17	**Group 2 (>1 to <2mm, 90-83% Fill) n=32**	**Group 3 (≥2mm, <83% Fill) n=18**	**P Value**
Mean canal diameter, (SD), mm	10.8 (0.20)	11.4 (0.26)	12.80 (0.95)	***0.0001****
Mean difference (SD), mm	0.78 (0.19)	1.39 (0.26)	2.75 (0.95)	***0.0001****
Mean time to union (SD), days	142.4 (54)	129.9 (48)	137.6 (89)	0.79

***Significance set at p<0.05, via one-way ANOVA**

See pages 47 - 108 for financial disclosure information.

WITHDRAWN

Morphological Variations and Regional Radii of Curvature of the Femur

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Background/Purpose: Prior analyses of the femoral radius of curvature (ROC) used only a few points to represent the femur, focused on the diaphysis, and did not include the distal metaphysis where intramedullary (IM) nail anterior cortical perforation may occur, and did not compare ROC in different regions of the femur. The curvature of contemporary femoral IM implants begins at the end of the generally straight proximal body and ends at the tip of the implant, which is placed at or distal to the distal condylar flare. Therefore the purpose of this study was to determine the femoral ROC of the region of the femur spanned by a modern nail in a large population using a novel automated technique and compare the ROC between the proximal and distal halves.

Methods: The sagittal ROC of the outer and inner anterior cortical boundaries of 1629 patients (3258 femurs) obtained from PE (pulmonary embolism) protocol CT scans were analyzed with a novel custom MATLAB script that automatically determined the location of femoral landmarks, adjusted for body position, and measured the ROC of the full region of interest and proximal and distal halves. Anterior cortical boundaries were automatically detected at each axial slice with an axial resolution of 5 mm. The region of interest was selected to correspond to the curved portion of most contemporary nails, or 15% of the length of the femur (approximately 6.5 cm) distal to the tip of the greater trochanter to 10% (approximately 4.4 cm) proximal to the distal end of the condyles. The length of the femur was defined from the tip of the greater trochanter to the distal end of the condyles while the axis of the femur was defined as a line between the tip of the greater trochanter and the distal femoral sulcus. Associations between age, femoral length, and height to ROC of the full region of interest and the proximal and distal halves were determined using bivariate analysis.

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Results: Mean age was 53.2 years (standard deviation [SD] 16.6). Mean height was 66.3 inches (SD 3.9). The mean outer and inner anterior ROC was 131.3 cm (SD 47.8) and 129.1 cm (SD 49.2) for the full length, 359.7 cm and 884.1 cm for the proximal half, and 1278.2 cm and 2874.6 cm for the distal half. ROC depended on location, height, and length of femur ($P < 0.001$). 10% and 54% of femurs had a lower ROC in the distal and proximal halves, respectively, than of the full length. ROC of the proximal or distal halves was not dependent on age nor length.

Conclusion: The mean femoral ROC of the anterior inner cortex of the region spanned by the curved portion of an IM nail is smaller than most contemporary nails, which are accommodated for by the medullary canal. The majority of the inner anterior cortical curvature of the femur occurs in the proximal half. 1 in 10 femurs will have a distal half that is more curved than its full length and may be at increased risk for anterior cortical perforation. The length of the femur had a significant association with ROC. When broken down by tertiles, the shorter third of femurs had a mean ROC of 119 cm and the longer third 139 cm ($P < 0.001$). However, the ROC of the proximal or distal halves of the femur did not depend on length. These findings have implications for short and long nail design.

See pages 47 - 108 for financial disclosure information.

The Stability of Fixation of Proximal Femoral Fractures: A Radiostereometric Analysis

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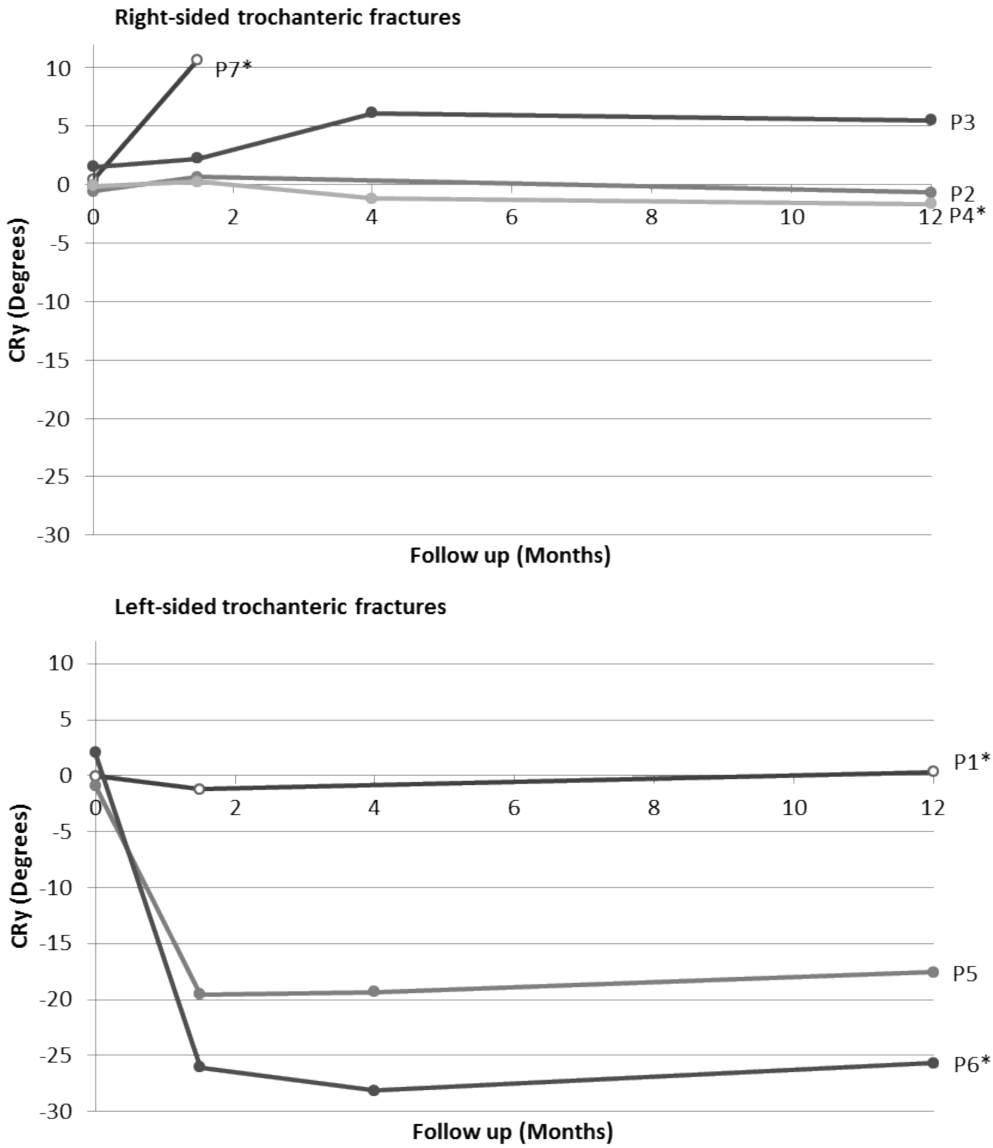
Background/Purpose: Rotational instability of the fracture-implant complex is thought to be a significant cause of fixation failure in proximal femoral fractures and may even be a key denominator and predictor of the most common fixation-related complications. However, the extent of rotational instability in hip fractures treated with modern implants has never been quantified in detail. Rotational instability is difficult to track using standard imaging techniques. However, segment motion (eg, motion between the fracture fragments) can be accurately measured by radiostereometric analysis (RSA). The aim of this study was to use RSA to quantify the movement of proximal femur fragments after fixation with the most commonly used methods of osteosynthesis (GN [Gamma nail], DHS [dynamic hip screw], and CS [cannulated screws]).

Methods: A total of 15 patients with an undisplaced femoral neck fracture (AO31-B1 and B2), treated with either a dynamic hip screw or three cannulated hip screws, and 16 patients with an AO31-A2 trochanteric fracture treated with a dynamic hip screw or a Gamma nail, were included. RSA was used at 6 weeks, 4 months, and 12 months postoperatively to evaluate shortening and rotation.

Results: Migration could be assessed in ten patients with a fracture of the femoral neck and seven with a trochanteric fracture. The RSA migration profiles showed that, until 4 months postoperatively, substantial translational instability is present in both fracture types. After this period stabilization occurs. By 4 months postoperatively, a mean shortening of 5.4 mm (range, -0.04 to 16.1) had occurred in the femoral neck fracture group and 5.0 mm (range, -0.13 to 12.9) in the trochanteric fracture group. A wide range of rotation occurred in both types of fracture. Right-sided trochanteric fractures seem more rotationally stable than left-sided fractures (Fig. 1).

Conclusion: The RSA migration profiles showed that, until 4 months postoperatively, substantial translational instability is present in both nondisplaced femoral neck fractures and AO31-A2 trochanteric fractures treated with the most commonly used implants. Left-sided trochanteric fractures treated by DHS or intramedullary fixation seem to be more rotational instable than right-sided fractures. Since rotation is most probably due to rotation of the medial fragment around the hip screw(s), rotation-preventing screw systems or cement augmentation of the hip screw may prove increasingly important in elderly hip fracture patients with poor bone stock. Future RSA hip fracture research may help develop risk profiles for adverse outcome and quality control tools for optimal fracture reduction and implant positioning.



See pages 47 - 108 for financial disclosure information.

The Effect of Helmet-Use on Motorcycle Trauma Outcomes

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Background/Purpose: Partial motorcycle helmet laws have proven to be inadequate, as states with such laws have reported helmet use rates as low as 44%, accompanied by a steady rise in motorcyclist hospitalizations and fatalities. In this retrospective cohort study, we evaluated motorcycle trauma data at a regional Level I trauma center over a 12.5-year time period. The goal was to investigate the clinical and economic effects of the use of motorcycle helmets. We hypothesized that non-helmeted patients would have worse injury profiles and increased treatment costs. We also predicted that alcohol and drug use would not significantly alter these outcomes.

Methods: A retrospective review was conducted using data from a Level I trauma registry, from July 2, 2002 to December 31, 2013. All patients admitted to the hospital after a motorcycle crash were included in the study. Patients were stratified into helmeted and non-helmeted cohorts. Group differences were compared using Wilcoxon test for continuous variables and chi-square test for dichotomous outcomes. Regression models were created to evaluate predictors of helmet use, alcohol and drugs as confounding variables, and factors that influenced hospital costs.

Results: The registry included 986 eligible patients. Of this group, 335 (34%) were helmeted and 651 (66%) were non-helmeted. Age and alcohol/drug use were negative predictors of helmet use. Overall, non-helmeted patients had a worse clinical presentation, with lower Glasgow Coma Scale (GCS), higher ISS, higher incidence of loss of consciousness (LOC), longer intensive care unit (ICU) admissions, and higher incidence of head or face injuries. Non-helmeted patients were also twice as more likely to die from their injuries. Financially, non-helmeted patients incurred mean hospital costs of $18,458 while helmeted patients incurred $14,970. ISS, GCS, and ICU length of stay were correlated with increased hospital costs. Alcohol or drug use did not significantly affect hospital outcomes, and was a nonsignificant predictor of patient mortality when compared to helmet use.

Conclusion: Helmet use is associated with lower injury severity and increased survival after a motorcycle accident. These outcomes remained consistent even after controlling for alcohol and drug use. The medical and financial impact of a partial helmet law is devastating; these outcomes support stronger helmet education and enforcement in states with such laws.

Table 1. Demographic Information, Injury Profile and Outcome

	Helmet (n = 335)	No helmet (n = 651)	*p*-Value
Demographics			
Male (%)	301 (90.9)	574 (88.1)	NS
Age (years)	34.4	38.8	< 0.0001
Admission variables			
SBP	126	128	NS
LOC	95	245	0.003 (OR1.68)
GCS	14	13.2	< 0.0001
ISS	13.6	15.7	0.002
# of transfers	54	111	NS
Hospital course			
ICU LOS (d)	1.3	2.4	0.001
Ventilator use (d)	5.2	6.6	NS
OR visits (%)	61 (18.2)	116 (17.8)	NS
Hospital LOS (d)	7	8.5	NS
Injury incidence (%)			
Head	104 (31)	378 (58.1)	< 0.0001 (OR 3.08)
Face	69 (20.6)	305 (46.9)	< 0.0001 (OR 3.4)
Neck	4 (1.2)	5 (0.8)	NS
Chest	156 (46.6)	291 (44.7)	NS
Abdomen	78 (23.2)	138 (21.1)	NS
Cervical spine	24 (7.2)	69 (10.6)	NS
Thoracic spine	35 (10.4)	56 (8.6)	NS
Lumbar spine	33 (9.9)	63 (9.7)	NS
Upper extremity	198 (59.1)	379 (58.2)	NS
Lower extremity	228 (68.1)	458 (70.3)	NS
Mortality (%)	14 (4.2%)	49 (7.5%)	0.042 (OR 1.87)

SBP = Systemic Blood Pressure, LOC = Loss of Consciousness, GCS = Glasgow Coma Scale, ISS = Injury Severity Score, ICU = Intensive Care Unit, LOS = Length of Stay, d = days

Table 2 Charges and Payer Distribution

	Helmet (n = 335)	No helmet (n = 651)	*p*-Value
Mean charges (SE)	$14,970 ($818)	$18,458 ($723)	0.175
Private (%)	201 (60.0)	359 (55.1)	NS
Public (%)	101 (30.2)	236 (36.3)	0.060
Uninsured (%)	23 (6.9)	43 (6.6)	NS
Other (%)	10 (3)	13 (2)	NS

See pages 47 - 108 for financial disclosure information.

Table 3 Results by alcohol/drug use

	No alcohol or drugs			Alcohol or drugs		
	Helmet (n = 246)	No helmet (n = 402)	*p*-Value	Helmet (n = 89)	No helmet (n = 249)	*p*-Value
Demographics						
Male (%)	219	354	NS	82	220	NS
Age	35	38	.001	33	40	< .0001
Admission						
SBP	126	129	NS	128	126	NS
LOC	73	131	NS	22	114	< .0001
GCS	14	13.3	.001	13.7	13.1	.022
ISS	13.8	15.3	.049	13.2	16.4	.024
Transfers	40	72	NS	14	39	NS
Hospital course						
ICU time	.9	2.5	< .0001	2.5	2.3	NS
Ventilator days	4.4	7	NS	6.4	6.1	NS
OR visits	43	77	NS	18	39	NS
Hospital LOS	6.1	9.7	NS	9.5	8.2	NS
Mortality	12	33	NS	2	16	NS
Mean charges	$12,801	$18,643	.067	$20,967	$18,158	NS

Multidisciplinary Malnutrition Screening Program in Orthopaedic Trauma Patients

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Background/Purpose: Postoperative complications in orthopaedic trauma patients are significant contributing factors to the cost of health care and lead to patient morbidity. A potentially modifiable risk factor known to contribute to postoperative complications is malnutrition. Studies have demonstrated that patients with an albumin level less than 3.5 are at a greater risk of surgical site infections in elective spine surgery and arthroplasty. However, there is little information about the results of a screening/treatment program for orthopaedic trauma patients with malnutrition. The purpose of our study was to introduce a malnutrition screening and treatment protocol for orthopaedic trauma patients to identify the incidence of malnutrition and determine the most effective screening techniques.

Methods: An IRB-approved prospective study was performed to enroll patients greater than age 18 years who presented to our institution over 5 consecutive months with acute operative orthopaedic injuries in a malnutrition screening and treatment protocol. Malnutrition screening consisted of serum albumin, transferrin, total lymphocyte count, and vitamin D. Additionally, patients were given a malnutrition screening questionnaire. The screening questionnaire identified high-risk patients and initiated a formal evaluation by a board certified dietitian to confirm the diagnosis and give recommendations on diet supplementation.

Results: 206 patients underwent operative treatment of orthopaedic fractures over the study period. 181 patients (88%) had laboratory testing for albumin, 172 patients (83%) for transferrin, 140 patients (68%) for total lymphocyte count, 177 patients (86%) for vitamin D, and 198 (96%) completed a nursing administered screening questionnaire. 91 patients (51%) had low albumin levels (<3.5 g/dL). 98 patients (57%) had low transferrin levels (<200 mg/dL). 37 patients (26%) had low total lymphocyte counts (<1000/mm3). Polytrauma patients had wide variability in their transferrin levels and/or total lymphocyte count over short periods of time during their hospital stay. 95 patients (54%) had low vitamin D levels (<20 ng/mL). 43 patients (22%) were screened as high risk for malnutrition on the questionnaire and were evaluated by a dietitian. There were three wound-related complications within the screened group. The complications included persistent wound drainage in two patients requiring oral antibiotics with no need for operative irrigation and debridement. One of these patients had decreased levels of albumin, transferrin, and vitamin D. The other patient had no alterations in their screening test. The third patient had early hardware failure with no evidence of infection.

Conclusion: Malnutrition is a common problem in orthopaedic trauma patients. A cost-effective program to identify at-risk patients is needed. In this series, low albumin and vitamin D levels were common, but these studies may overdiagnose malnutrition in trauma patients. Transferrin and total lymphocyte counts vary widely in trauma patients, likely due to the initial trauma and hemorrhage and are likely not informative. A screening questionnaire is easily administered and effective to identify high-risk patients and combined with evaluation by a dietitian may supplant the need for costly laboratory studies.

See pages 47 - 108 for financial disclosure information.

Risk of Second Hip Fracture Persists for Years After Initial Trauma

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Purpose: Secondary prevention following hip fracture is underprescribed. This may be due to the lack of knowledge of who to target and when to target them. Presently secondary prevention is directed at women who suffer from high rates of second hip fracture, particularly in the early years post fracture. The risk of second hip fracture by certain times also depends on the death rate (competing risk) yet previous studies have failed to censor who have died. Here we estimate and compare the risk of second hip fracture for surviving women and men in the 10 years post fracture.

Methods: We retrieved 38,383 hospitalization records of patients aged 60 years or older, who were discharged alive after index admission for surgical treatment of a nonpathologic hip fracture from April 1, 1990 to March 31, 2005 from our jurisdiction's administrative health database, and had no hip fracture hospitalizations before April 1, 1990. The outcome variable was the time between discharge date for index hospitalization and admission date for a subsequent hip fracture. We estimated the conditional probability function of second hip fracture using the ratio of the cumulative incidence of second hip fracture over the complement of the cumulative incidence of death by follow-up year. We tested for differences in the conditional probability function of second hip fracture between women and men using Pepe's 2-sample test and a proportional-odds model. By fitting this model, we obtained a series of odds ratios (ORs) comparing the risk of another fracture between surviving women and men for every follow-up year and the weighted average of these ORs. We tested whether the serial ORs are equal using time-dependence test.

Results: During 10 of follow-up, 21,428 (56%) died before sustaining second hip fracture, and 2902 (8%) sustained second hip fracture. In women and men combined, the percentage of second hip fracture for the surviving post-fracture population increased steadily with time, reaching 34% (95% confidence interval [CI]: 33-35) by 10 years. The percentage was higher in women than in men: 2% vs 2%, 5% vs 4%, 9% vs 7%, 15% vs 13%, and 35% vs 30% at 1 year, 2, 3, 5, and 10 years, respectively (figure, left panel 2-sample test: P = 0.02, crude OR = 1.25 [95% CI: 1.13-1.39]). However, after adjustment for baseline age, fracture type, period, and hospital length of stay, the percentage of second hip fractures among survivors did not differ between women and men, OR = 1.09 (95% CI: 0.98-1.21) (figure, right panel). The time-dependence test rejected the equality hypothesis for serial ORs of second hip fracture for women relative to men (P = 0.02).

Conclusion: Challenging common belief, we report that women and men remaining alive post hip fracture are at an equal risk of second hip fracture, and therefore both should be considered for secondary prevention. The risk of second hip fracture persists for at least 10 years among hip fracture survivors. Secondary prevention should be considered early post fracture; however, patients with a delay to secondary prevention therapy may still benefit at any stage post fracture.

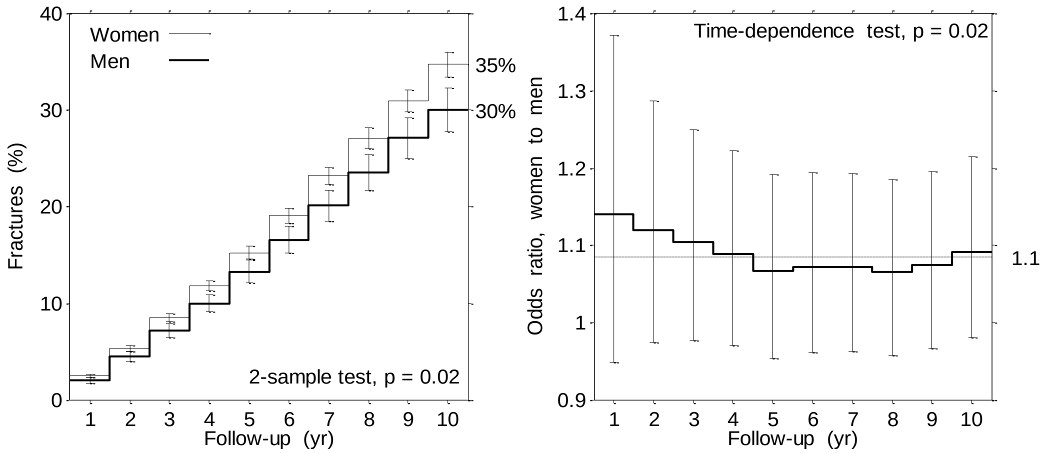

Figure. Risk of second hip fracture given a death did not occur by follow-up year, for women and men, (left panel). Adjusted odds ratios for second hip fracture comparing women and men, by follow-up year (right panel). The dashed line represents the weighted average of the adjusted odds ratios. Vertical bars represent 95% confidence intervals.

POSTER ABSTRACTS

Extensor Mechanism Injuries of the Knee: Patient Demographics and Comorbidities from a Review of 726 Patients

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Purpose: Extensor mechanism injuries of the knee are common injuries. The purpose of this study was to describe and compare extensor mechanism injuries with regard to age, gender, body mass index (BMI), and medical comorbidities.

Methods: Patients undergoing surgical management of extensor mechanism injuries were queried at two separate institutions from 1986-2012. Data included age at time of surgery, gender, height, weight, and the presence of medical comorbidities. Chronic disruptions of the quadriceps or patellar tendon, those undergoing revision surgery, and injuries in the setting of total knee arthroplasty were excluded.

Results: 726 patients were included: 427 (58.8%) patella fractures (OTA classification 34 A-C), 210 (28.9%) quadriceps ruptures, and 89 (12.3%) patellar tendon ruptures. 67% of patella fractures were in females while 91% of quadriceps tendon and 95.5% of patellar tendon ruptures occurred in men ($P < 0.001$, Fig. 1). Age distribution was significantly different between the groups with quadriceps tendon ruptures averaging 61 ± 13.06 years (range, 20-92), patella fractures averaging 56.3 ± 17.4 years (range, 16-91), and patellar tendon ruptures averaging 39.5 ± 12.2 years (range, 18-72). Patella fractures showed a bimodal distribution with regard to both age and gender: the median age of females was 62 years (16-91) and the median age of males was 47 years (16-91), $P < 0.001$. BMI varied significantly between cohorts with patella fractures averaging 25 ± 5.2 kg/m2, patellar tendon ruptures averaging 28.7 ± 4.97 kg/m2, and quadriceps tendon ruptures averaging 30 ± 6.05 kg/m2 ($P < 0.001$). 96% of females with quadriceps or patellar tendon injuries had an underlying medical comorbidity compared with 68% of males ($P = 0.008$). Of these comorbidities, 61% were considered to be risk factors for tendinopathy in the female cohort compared to only 34% in males ($P = 0.008$).

Conclusion: Our series of extensor mechanism injuries, the largest in the current literature, reveals striking demographic patterns. Females with extensor mechanism injuries are more likely to be older and to sustain patella fractures compared to men. Young males are more likely to sustain patellar fractures or patellar tendon ruptures; however, 43% of patients with patellar tendon ruptures were over the age of 40 years. Medical comorbidities are common in patients with tendon ruptures, but significantly more common in females when compared to males.

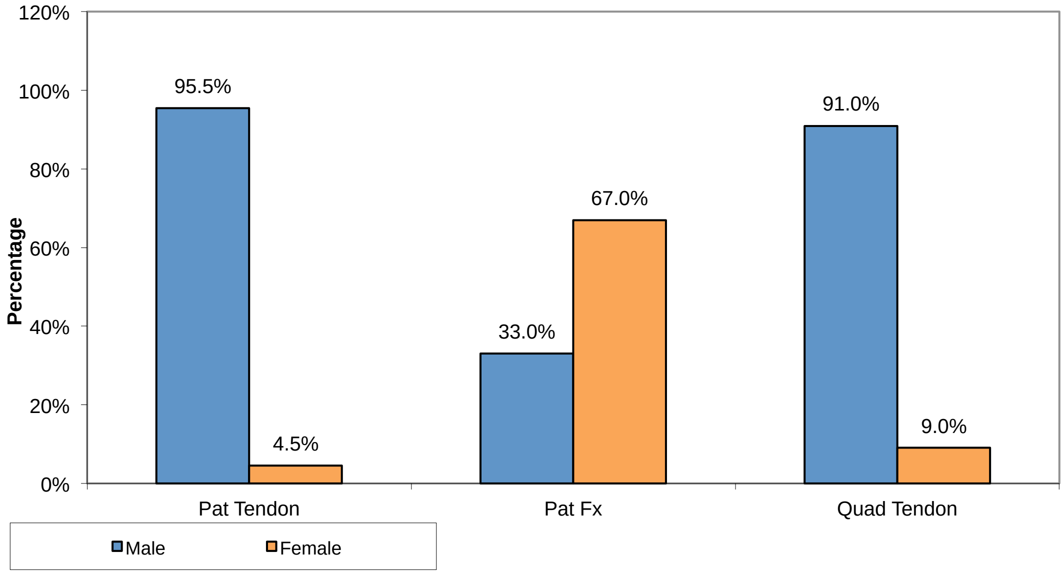

Figure 1: Percentage of male and female patients divided by injury type.

POSTER ABSTRACTS

See pages 47 - 108 for financial disclosure information.

Does Partial Patellectomy Lead to Patella Baja?

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Background/Purpose: Partial patellectomy has been described since 1935 with mixed results in the literature. The outcomes of this technique are often grouped with all open reduction techniques. We retrospectively studied a cohort of partial patellectomy patients to determine their clinical and functional outcomes, and to evaluate whether they developed the complication of patella baja.

Methods: 32 patients were identified who underwent partial patellectomy with patellar tendon advancement from 2009-2013. Charts were retrospectively reviewed to record range of motion and quadriceps strength at last follow-up. Final follow-up radiographs were examined and the Hepp method of measuring patellar height was applied, as this is the only described method still applicable given the change in patellar anatomy (Fig. 1) Functional outcomes were assessed with the Marx scale and the IKDC (International Knee Documentation Committee) score through interview of the patients.

Results: Follow-up notes and radiographs were available on 32 patients. The average final follow-up was 9.4 months (range, 3-84). 27 patients achieved full extension postoperatively, and 24 reached at least 100° of flexion. 16% of patients were documented as having 3/5 quadriceps strength; the remaining patients were graded as 4/5 to 5/5. Radiographically, 42% patients had at least one of the Hepp measurements indicate patella baja, and five of those demonstrated patella baja with both measurements. 17 (53%) patients had ipsilateral lower extremity injuries. 18 patients (9 with ipsilateral injuries) were available by phone to answer the Marx and IKDC functional outcome surveys which demonstrated an average Marx scale of 2.8 (range, 0-12; 16 would be a perfect score) and an average IKDC score of 45.71 (range, 12.64-81.61; 100 would be a perfect score). The patients with ipsilateral injuries scored an average IKDC of 50 and the patients without ipsilateral lower extremity injuries scored an average IKDC of 40.1 (P = 0.28). These were not significantly different. The Marx scores for these groups were identical.

Conclusion: This is a retrospective study to specifically examine clinical, radiographic, and functional outcome results of partial patellectomies for patella fractures. This technique is useful for those comminuted distal pole patella fractures and also due to the fact hardware prominence and need for removal is not an issue. Our clinical results indicated reasonable clinical function of the affected leg. Patellar height measurements indicated that patella baja was common--42%. As with recent studies, the functional outcome scores were poor. This could be due in part to the high rate of patella baja. Further studies are warranted as we are finding out patella fractures, no matter what the fixation type, are not benign injuries.

Clinical and Radiographic Predictors of Acute Compartment Syndrome in Tibial Plateau

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Purpose: The aim of this study was to retrospectively evaluate the relationship between epidemiological, clinical, and radiographic factors of patients with tibial plateau fractures and the development of acute compartment syndrome.

Methods: 265 adult patients sustaining 269 intra-articular tibial plateau fractures between January 2005 and December 2009 were included in this retrospective cohort study. The outcome measure was acute compartment syndrome, which was clinically diagnosed. Patient-related (age, sex), fracture-related (mechanism of injury, closed vs open fracture), and radiological parameters (AO/OTA and Schatzker classifications, presence or absence of a noncontiguous tibial shaft or pilon fracture or knee dislocation, tibial widening ratio, femoral displacement ratio, anatomical axis displacement direction) were evaluated regarding their potential association with acute compartment syndrome.

Results: Overall, acute compartment syndrome occurred in 28 (10.4%) of 269 tibial plateau fractures. Four patients presented bilateral tibial plateau fractures; of them, 2 had unilateral, but none had bilateral acute compartment syndrome. Univariate analysis showed that age <45 years (P = 0.014), male sex (P = 0.011), open fracture (P = 0.015), noncontiguous tibia fracture or knee dislocation (P = 0.001), higher Schatzker grade (IV-V-VI; P <0.001), higher AO/OTA classification (type 41-C; P <0.001), tibial widening ratio higher or equal to 1.05 (P = 0.004), and femoral displacement ratio higher or equal to 0.08 (P = 0.015) were all associated with an increased rate of acute compartment syndrome. Mechanism of injury other than fall from own height, and anatomical axis displacement direction were not associated with acute compartment syndrome. In multivariable regression analysis, the presence of a noncontiguous tibia fracture or knee dislocation (P <0.001), and a higher AO/OTA classification (P <0.001) remained statistically significantly associated with the development of acute compartment syndrome.

Conclusion: Two parameters related to the occurrence of acute compartment syndrome have been highlighted in this study. They may be especially useful when clinical findings are difficult to assess (doubtful clinical signs, obtunded, sedated or intubated patients). However, larger studies are mandatory to confirm and refine the prediction of compartment syndrome occurrence.

See pages 47 - 108 for financial disclosure information.

The Treatment of Difficult Patella Fractures with the Multiple Wire and Tension Band Technique

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Purpose: Our objective was to describe a technique applicable to osteoporotic and comminuted patella fractures as well as for revision surgery of failed patellar fixation. The standard tension band technique can be adapted to situations where multiple fracture planes are involved, to revision surgery, for use in osteoporotic bone, and for situations where there is concern for fixation fragility using standard tension band methods.

Methods: This is a retrospective descriptive case series of consecutive surgically treated patellar fractures using a technique with combinations of multiple wires and tension bands. Constructs were made using #6 (8.0 metric) sternal wires tensioned or cerclaged around two or more Kirschner wires and/or screws to address the major fracture planes while maintaining low-profile fixation. Data were collected at preoperative, intraoperative, and postoperative time points. The primary outcome measure was loss of fixation that necessitated revision surgery. Secondary outcomes included the need for implant removal, postoperative infection, and any need for further surgery associated with initial patella fracture fixation (chondroplasty, lysis of adhesions, manipulation, etc).

Results: 107 patellar fractures were fixed at our institution between 2000 and 2014. 73 patellar fractures were treated with the multiple wire and tension band technique. The incidence of fixation failure was 4.1%, 1 for postoperative peri-ardware failure after a fall and 2 for failure of fixation. A postoperative infection occurred in 2.7% of patients. 38 patients (52.1%) underwent removal of hardware, 1 for infection and 37 for prominent symptomatic hardware. Multivariate analysis demonstrated significantly increased incidence of removal of hardware in patients with American Society of Anesthesiologists (ASA) I/II ($P = 0.002$). Additionally, 6.8% of patients needed a patella-related surgery, including 3 patients who needed manipulations, 1 patient who underwent arthroscopic chondroplasty, and 1 who needed a patellar tendon repair.

Conclusion: The rate of fixation failure and postoperative infection for difficult patellar fractures using multiple wire and tension band constructs was low and less than many retrospective studies describing single tension band or cannulated screw fixation techniques. However, symptomatic hardware needing removal was the most common complication observed with this technique and more frequent than rates found in the literature using other standard techniques. Moreover, analysis demonstrated that healthier patients had significantly higher incidence of hardware removal.

POSTER ABSTRACTS

Posttraumatic Total Knee Arthroplasty Continues to Have Worse Outcome Than Total Knee Arthroplasty for Osteoarthritis

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***Stephen Sems, MD**[1]; Rafael Sierra, MD[1];*
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[2]Mayo Grad School of Medicine, Rochester, Minnesota, USA

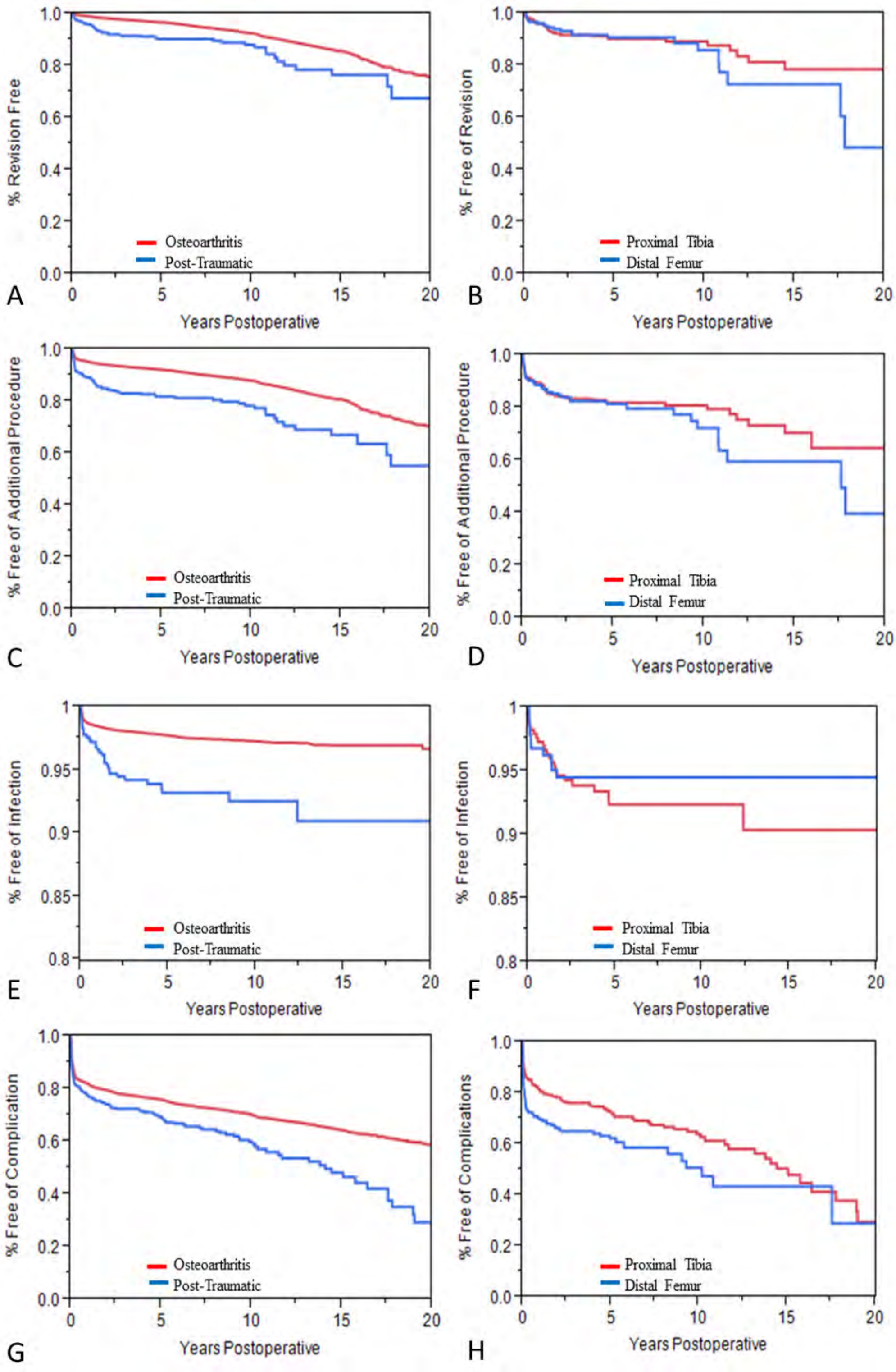
Background/Purpose: Periarticular fractures around the knee are potentially devastating injuries. Following these injuries, patients are predisposed to posttraumatic arthritis. Previous studies have shown that patients who undergo a total knee arthroplasty (TKA) following a distal femoral and/or tibial plateau fracture may have inferior results. However, these studies have relatively few subjects and separate distal femur and tibial plateau fractures. The purpose of this study was to evaluate the long-term outcomes of patients undergoing TKA following periarticular knee fractures.

Methods: Using our institution's total joint registry, we identified 531 patients who underwent a TKA following an ipsilateral distal femur or tibial plateau fracture from 1990-2012. Kaplan-Meier survival outcomes were assessed with a focus on need for reoperation, infection, and revision TKA at a mean follow-up of 5 years. Overall revision-free survival was compared to 19,641 patients who underwent primary TKA for osteoarthritis (OA) during the same time interval. Mean age was 62 years (range, 19-89) at the time of the TKA, with 60% being female.

Results: Patients with a history of a distal femur or proximal tibia fracture had a significantly increased risk of revision TKA (hazard ratio [HR] 2.23, P <0.0001), need for an additional procedure (HR 2.20, P <0.0001), postoperative infection (HR 2.85, P <0.0001), and postoperative complications (HR 1.44, P <0.0001) compared to patients with a diagnosis of OA. There was no difference in the need for revision TKA (HR 1.18, P = 0.53), need for an additional procedure (HR 1.21, P = 0.34), or postoperative infection (HR 0.79, P = 0.53) when comparing patients with a previous distal femur fracture to those with a previous proximal tibia fracture.

Conclusion: Patients with TKA following a periarticular fracture have worse overall revision-free survival compared to those undergoing TKA for OA. Our study shows that rates of complications in this cohort of patients are high, with 1 in 4 patients requiring revision TKA by 15 years.

See pages 47 - 108 for financial disclosure information.


A
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Distal Femur
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Early Posteromedial Incision Does Not Increase Wound Complications or Total Operative Time in AO/OTA 41 Type C Tibial Plateau Fractures

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[2]Upstate Medical University, Manlius, New York, USA;
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Background/Purpose: The current recommendation for definitive treatment of bicondylar tibial plateau fractures (AO/OTA 41C) is open reduction and internal fixation (ORIF) of both medial and lateral columns with dual-plate fixation through two incisions. Use of a two-incision technique has been shown to reduce soft-tissue complications associated with dual plating through a single anterior incision. We currently use a modified technique for initial stabilization wherein bicondylar tibial plateau fractures are treated with early posteromedial fixation at the time of provisional stabilization through a posteromedial incision. Our technique facilitates medial column reduction and converts an AO/OTA type 41C fracture to a 41B fracture. This report describes a retrospective comparison of surgical times and wound complications associated with patients treated with early "41C to 41B" technique and staged definitive fixation of the lateral column, and those treated with dual-incision, dual-plate fixation (DIDP) at the time of definitive fixation. Our hypothesis is that the 41C to 41B technique does not increase overall surgical time, or result in increased wound complications.

Methods: Bicondylar AO/OTA 41C-type fractures presenting to a Level I trauma center in a 7-year period were included for review. All patients were treated by two trauma fellowship-trained surgeons with the either the 41C to 41B technique as described below, or through a DIDP fixation as previously described. Patient records were reviewed for total surgical time (provisional fixation plus definitive fixation) and wound complications. Both techniques involved ORIF with dual plating through a posteromedial incision and an anterolateral incision. After initial evaluation, patients requiring provisional stabilization were brought to the operating room and placed in spanning external fixation. Patients undergoing DIDP had no further fracture treatment at that time. Patients undergoing stage 41C to 41B technique had the medial plateau segment stabilized with a unicortical posteromedial antishear plate construct. Following appropriate soft-tissue maturation, the patients were returned to the operative suite for definitive ORIF.

Results: 50 bicondylar tibial plateau fractures in 50 patients met inclusion criteria and were included in the study. 33 patients were treated with DIDP fixation and 17 patients were treated with 41C to 41B protocol. Average follow-up for the 41C to 41B group was 11.3 months. Average surgical time was 178 ± 37 minutes with two wound complications, with one wound requiring surgical debridement. Average follow-up for the DIDP group was 17.6 months. Average surgical time was 172 ± 55 minutes with two wound complications, with one wound requiring surgical debridement. There was no significant difference in operative times (P = 0.52) or wound complications (P = 0.59).

Conclusion: Early posteromedial fixation does not result in increased wound complications in our limited series, and does not increase the overall surgical time. Early posteromedial fixation may be useful in obtaining early control of the medial column in these types of injuries.

See pages 47 - 108 for financial disclosure information.

Risk Factors for Infection After Operative Fixation of Tibial Plateau Fractures

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[2]University of Alabama at Birmingham, Birmingham, Alabama, USA

Background/Purpose: Tibial plateau fractures are challenging to treat, especially due to the incidence of postoperative infections. The purpose of this study was to identify injury, patient, and surgical risk factors for deep infection in patients with tibial plateau fractures undergoing operative fixation. Our hypotheses were that certain patient factors (tobacco use and diabetes) and injury characteristics (concomitant compartment syndrome, Schatzker types IV-VI fractures, and open fractures) would be associated with infection.

Methods: A retrospective review was undertaken to identify all patients with tibial plateau fractures over a 10-year period (2003-2012) who underwent open reduction and internal fixation. A total of 531 patients were identified who met the inclusion criteria. Several patient and clinical characteristics were recorded, and those variables with a significant association ($P < 0.05$) with postoperative infection were further analyzed using a multivariate analysis.

Results: 58 (10.9%) of the 531 patients developed a deep infection. The average length of follow-up for patients was 19.5 months. Methicillin-resistant Staphylococcus aureus (MRSA) was the most common species, and it was isolated in 26 patients (44.8%). Open fractures, the presence of compartment syndrome, and a Schatzker type of IV-VI were found to be independent risk factors for deep infection.

Conclusion: The rate of deep infection remains high after operative fixation of tibial plateau fractures. Patients with risk factors for infection should be counseled on the possibility of reoperation, and surgeons should consider MRSA prophylaxis in those patients who are at higher risk.

Indirect Medial Reduction and Endosteal Strut Graft Support of Complex Tibial Plateau Fractures with Diaphyseal Extension

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[2]Wake Forest University School of Medicine, Winston Salem, North Carolina, USA;
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Background/Purpose: Successful treatment of complex proximal tibial fractures with diaphyseal extension remains a challenging problem with associated residual malalignment and wound complications. Lateral plating with a fixed-angle implant is commonly used to address these injuries. An additional buttress plate applied through second medial incision can be used to address medial fragments, but this further disrupts the soft-tissue envelope. We aimed to evaluate the radiographic and clinical outcomes of a fixation construct that consists of a laterally applied fixed-angle implant augmented with an endosteal fibula strut allograft to support of the medial side (Fig. 1).

Methods: A total of 17 patients with closed proximal tibial fractures treated with this construct were initially reviewed. 15 met inclusion criteria with >6 months of radiographic and clinical follow-up. Nine patients had an additional reconstruction plate added through the same lateral incision, and 2 patients had a second posteromedial incision to place a buttress plate for fixation of a posteromedial coronal shear fragment. The remaining 4 patients had only the lateral fixed-angle implant and endosteal allograft. Main outcomes measurements included (1) radiographic: angular alignment both immediately following surgery and at time of osseous union; (2) functional: Knee Outcome Survey (KOS), Lower Extremity Functional Scale (LEFS), Short Form (SF)-36, and visual analog scale (VAS) for pain; and (3) clinical: wound complications and range of motion.

Results: The average age was 56.2 years (range, 29-85). Average follow-up was 11.9 months (±6.17). AO/OTA fracture types included 5 41-C2 and 10 41-C3. Spanning external fixation was placed in 80% (12 of 15) patients preoperatively, and fasciotomies (1 to 4 compartments) were performed in 14 of 15 patients. Postoperative alignment ranged from 2.0° of valgus to 5.0° of varus. There were no postoperative malreductions (varus/valgus alignment of >5.0°). Mean change in alignment during the follow-up period was 0.7° (±0.91°). Postoperative alignments and maintenance of alignment compare favorably to historical controls, which reported 15% postoperative malreduction and 24% residual malalignments (change over time of >5°). Four (27%) required muscle rotational flaps to cover the wounds. All patients achieved osseous union and were encouraged to start full weight bearing at an average of 15.0 weeks (±6.6) postoperatively. One patient (6.6%) suffered a deep infection requiring irrigation and debridement of the wound (reported in 12% of historical controls). Two patients presented with radiological signs of delayed osseous union, were treated with percutaneous placement of bone marrow stem cells and BMP (bone morphogenetic protein), and subsequently healed. Mean range of motion was 1.06° (±1.91°) of extension to 125.33° (±17.57°) of flexion. Ten patients completed subjective outcomes surveys and achieved good functional outcomes (KOS: 59.1 ± 13.05; LEFS: 60.3 ± 17.9; SF-36: Physical, 45.2 ± 7.5, Mental, 49.9± 8.75; and VAS: 3.05 ± 3.17).

See pages 47 - 108 for financial disclosure information.

Conclusion: The endosteal strut fibular allograft serves as an indirect reduction tool, provides mechanical support to the medial column, and increases fixation stability (by increasing bone stock and decreasing the screw working length), without affecting the medial soft tissue envelope. This novel construct resulted in excellent maintenance of reduction/alignment with high union rates, low wound complications, and good clinical outcomes. Figure 1. 65 year old male that suffered a closed 41C-2 proximal tibal fracture treated with this novel construct. Injury radiograph (left), 3D CT reconstructions (middle), and 12 months radiographs (right).

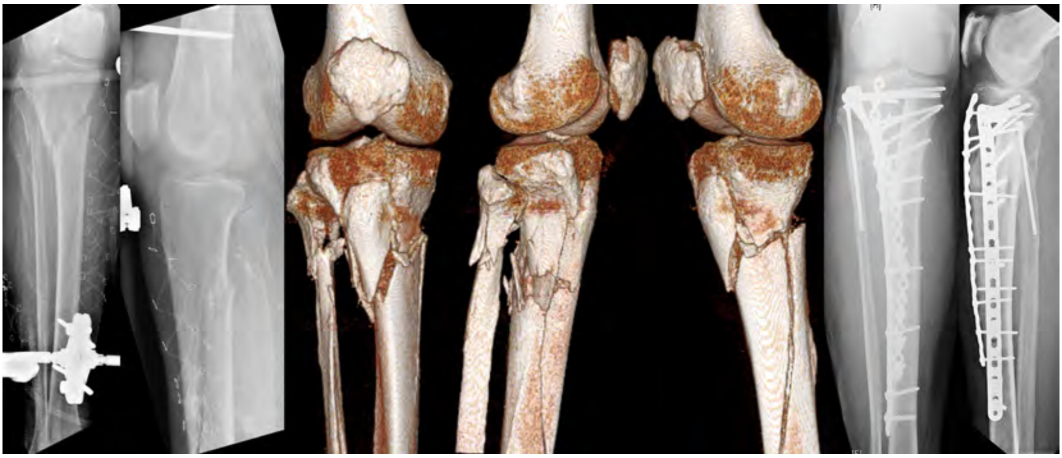

Figure 1. 65-year-old male who suffered a closed 41C-2 proximal tibial fracture treated with this novel construct. Injury radiograph (left), 3D CT reconstructions (middle), and 12-month radiographs (right).

Prospective, Multicenter, Observational Study Evaluating the Augmentation with Calcium Phosphate Cement (chronOS Inject) for Bone Defect After Internal Fixation of Proximal Tibial Fractures

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Purpose: The primary objective of this study was to observe the safety and the radiologic and clinical outcomes of chronOS Inject after having been used as bone void filler in internal fixation of proximal tibial fractures. Secondary objectives were to assess the surgeon's satisfaction in using chronOS Inject and patient satisfaction post surgery.

Methods: 36 proximal tibial fractures (Schatzker I-VI) with bone defect in 36 patients were prospectively enrolled. All fractures were treated with this bone void filler during internal fixation of proximal tibial fractures. All patients were evaluated preoperatively, at 6 weeks, and at 6 and 12 months postoperatively. The average age of patients was 55 years. Radiographic union and amount of articular subsidence were assessed by the investigator using plain films supplemented with CT scans. Pain, function, and adverse events were collected at all visits.

Results: 34 of 36 assessed patients achieved fusion at the site of chronOS Inject implantation. Mean time to union was calculated to be 7.5 months (standard deviation = 0.441), based on the Kaplan-Meier estimator of the survivorship function. No evidence of articular subsidence of >2 mm could be found at 6 weeks, while one patient showed evidence at 6 months that lasted throughout to the 12-month visit. Absorption rates were calculated from radiographs with the INFINITT program. After 6 weeks, 14% of the calcium phosphate cement was absorbed, at 6 months 37%, and at 12 months 64%. A statistically significant mean percent improvement from baseline was observed in physical composite score at month 12 ($P = 0.0166$) in the Short Form (SF)-12 health survey.

Conclusion: Augmentation with calcium phosphate cement prevented subsidence of articular fragment as the fracture healed, including elimination of morbidity related with bone graft harvesting.

POSTER ABSTRACTS

See pages 47 - 108 for financial disclosure information.

Traumatic Knee Dislocations in the Obese and Morbidly Obese From 2000 to 2010: Increased Incidence and Rate of Vascular Intervention

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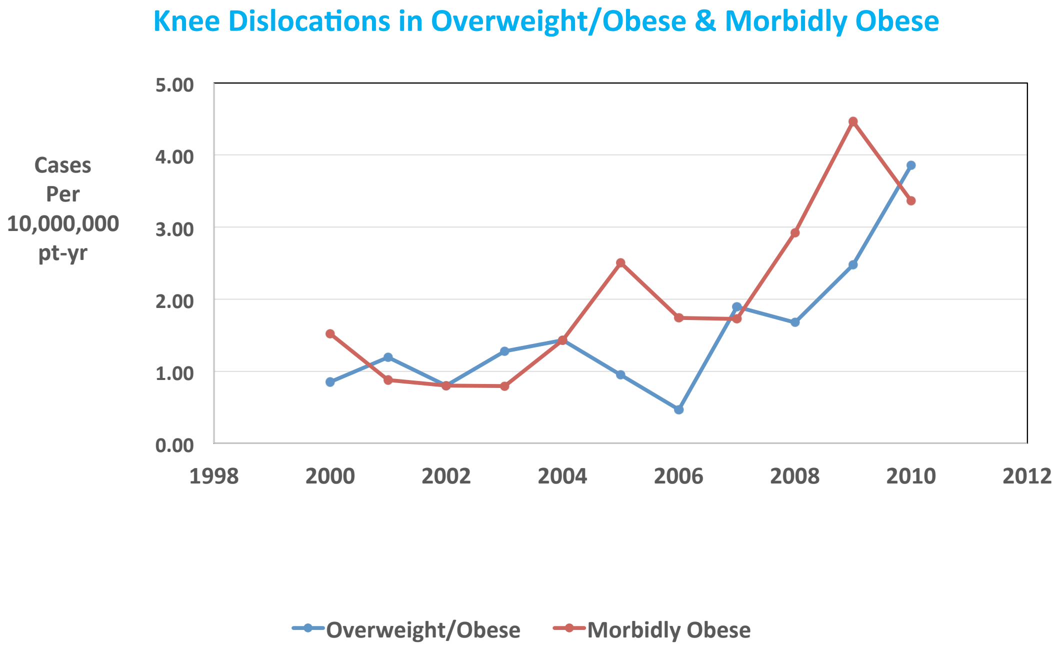
Purpose: Over the last 10 years, case reports have described low velocity knee dislocations in obese patients. Few studies have attempted to evaluate the association between obesity and knee dislocation. The purpose of this study was to use a large national epidemiologic database to analyze the association of both obesity and morbid obesity with closed knee dislocation and rate of vascular intervention.

Methods: The Nationwide Inpatient Sample (NIS) database was utilized to access U.S. inpatient data from 2000 to 2010. Only patients with noncongenital closed knee dislocations were included. Examined variables included patient age, sex, U.S. geographical region, overweight/obese or morbidly obese status, hospital length of stay (LOS), presence of vascular intervention (ie, peripheral shunt/bypass or other vascular procedure), and total inpatient hospitalization charge. Total annual case numbers and regional data were estimated by the Healthcare Cost and Utilization Project (HCUP) online query system. Overall annual dislocation incidence rates were calculated based on yearly U.S. Census estimates.

Results: Over an 11-year period from 2000-2010, a total of 12,188 knee dislocations were identified, including 1169 in overweight/obese patients (9.6%). The annual incidence of knee dislocations reported in patients diagnosed as overweight/obese and morbidly obese both increased over the 11-year time period (P <0.05 and P <0.01, respectively) (Fig. 1). The percentage in patients diagnosed as morbidly obese increased from 1.9% in 2003 to 10.9% in 2009. Overall annual incidence also increased during the study period (P <0.05). 58% of dislocations occurred in males. 24% of dislocations were reported in patients 45-64 years of age, while 51% were reported in the 18-44 age group (P <0.001). Of the four major U.S. geographical regions, 42% of dislocations occurred in the Southern region, nearly twice as many as in the Midwest, the next highest region (P <0.001). Average hospital LOS for the morbidly obese group (10.27 days) was greater than the overall average (7.78 days) (P <0.05). The average hospital cost was higher for both the overweight/obese ($67,200) and morbidly obese ($76,900) compared with the overall average ($58,400), although this difference was not significant (P >0.05). The overall rate of vascular intervention was 1.31%. However, 13.5% of overweight/obese patients (P <0.05) and 10.3% of morbidly obese patients (P <0.01) required a vascular intervention over the 11-year study period. Of morbidly obese patients, an average of 15.7% had vascular interventions reported over the last 3 years of the study (2008-2010) compared with 8.3% during the first 8 years (2000-2007) (P <0.05).

Conclusion: This study represents the largest number of closed knee dislocations presented to date. This study is the first to demonstrate significant increases in knee dislocation rates for both overweight/obese and morbidly obese patients. Annual overall incidence has also increased significantly over time. Additionally, the majority of cases occurred in the Southern region of the United States. Most importantly, vascular repairs were found to be far more common in both overweight/obese and morbidly obese patient groups compared to the overall population. Orthopaedic trauma and other surgeons should be on high alert when managing closed knee dislocations in obese and morbidly obese patients as a significant number may require prompt vascular intervention.



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Rate of Total Knee Arthroplasty After Tibial Plateau Fracture

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Background/Purpose: Intra-articular tibial plateau fractures are considered a risk factor for the subsequent development of osteoarthritis. These fractures are therefore routinely treated surgically to anatomically restore the articular surface of the knee, and prevent the premature onset of posttraumatic osteoarthritis. The purpose of our study is to determine the rate of total knee arthroplasty (TKA) following a tibial plateau fracture. Furthermore, the rate of conversion to TKA based on fracture severity according to the Schatzker classification will be evaluated.

Methods: A retrospective review of patients aged 18 years or older who had undergone surgical fixation of a tibial plateau fracture from January 2003 to December 2013 was undertaken. Patients were identified using Ministry of Health billing codes. Demographics, mechanism of injury, concomitant injuries, complications, and long-term outcomes were recorded. Each patient's preoperative imaging was reviewed, and fractures were classified according to the Schatzker classification, types I-VI. The rate of TKA was recorded as identified using ourLlocal Health Integration Network (LHIN) arthroplasty database.

Results: A total of 577 patients were identified using the Ministry of Health billing codes for surgically treated tibial plateau fractures. Patients whose preoperative radiographs were not available, or those patients who had been incorrectly identified, were removed. Therefore, a total of 453 tibial plateau fractures were classified according to the Schatzker classification. Of those, 2.4% (n = 11) went on to TKA.

Conclusion: Despite a significant injury to the articular surface of the knee, very few patients in our study population went on to require TKA following a tibial plateau fracture. These data support the efficacy of operative management of these fractures.

Incidence, Location, and Risk Factors for Articular Malreductions of the Tibial Plateau

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Background/Purpose: Tibial plateau fractures represent 1% of all fractures, with 70% involving the lateral plateau. Anatomic reduction of the articular surface is known to be associated with superior outcomes. The sensitivity of fluoroscopy has been questioned with respect to the accuracy of detecting malreductions, and the articular malreduction rate of these injuries is not well defined. The purpose of this study was to review CT scans following surgical fixation of tibial plateau fractures to define the incidence of articular malreduction and to map the location of the malreductions

Methods: De-identified postoperative CT scans were reviewed to identify tibial plateau malreductions with a step or gap greater than 2 mm, or condylar width greater than 5 mm. Three independent assessors reviewed the scans meeting criteria using Osirix DICOM (Digital Imaging and Communications in Medicine) software. Steps and gaps were mapped onto the axial sequence at the level of the joint line. Images were then matched to side and overlaid as best fit in Photoshop software to create a map of malreductions. A grid was created to divide the medial and lateral plateaus into quadrants to identify the density of malreductions by location. A multivariate regression model was used to assess risk factors for malreduction.

Results: 65 postoperative CT scans were reviewed. 21 reductions had a step or gap more than 2 mm for a malreduction incidence of 32.3%. The incidence in patients undergoing submeniscal arthrotomy or fluoroscopic-assisted reduction was 16.6% and 41.4%, respectively ($P < 0.001$). Side of injury, age, BMI (body mass index), AO fracture type, and use of locking plates were not predictive of malreduction. Malreductions were heavily weighted to the posterolateral tibial plateau.

Conclusion: The incidence of articular malreductions was high at 32.3%. Fluoroscopic reduction alone was a predictor for articular malreduction with most malreductions located in the posterolateral tibial plateau. Single orthogonal fluoroscopic views are likely inadequate to detect all malreductions and further work is needed to define optimal intraoperative imaging and techniques to address this area of the plateau.

See pages 47 - 108 for financial disclosure information.

BMI as a Predictor of Perioperative Complications Following Orthopaedic Trauma Surgery: An ACS-NSQIP Analysis

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Background/Purpose: Obesity is among the most common health conditions affecting orthopaedic patients, with a prevalence in the United States approaching two-thirds of the population. Obesity affects nearly every organ system and is associated with significant medical comorbidities. While the impact of obesity on total joint arthroplasty outcomes has been documented extensively in the literature, very few large-scale studies have explored the influence of obesity on outcomes following orthopaedic trauma. Utilizing the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, we sought to investigate the relationship between body mass index (BMI) and perioperative complications in orthopaedic trauma patients.

Methods: A prospective cohort of 56,299 patients was identified from the 2006 to 2013 ACS-NSQIP database using CPT codes for orthopaedic trauma procedures. Preoperative BMI was used to group patients into one of five categories: underweight (BMI <18.5 kg/m2), normal weight (18.5-24.9), overweight (25-29.9), obese (30-39.9), or morbidly obese (40 or higher). Perioperative complications within 30 days were recorded and categorized as minor (wound dehiscence, superficial wound infection, pneumonia, and urinary tract infection) or major (deep wound infection, organ space infection, myocardial infarction, pulmonary embolism, deep venous thrombosis, cerebrovascular accident, neurologic deficit, sepsis, septic shock, coma, and death). Using a multivariate logistic regression analysis controlling for age, smoking status, American Society of Anesthesiologists (ASA) score, and medical comorbidities, odds ratios (ORs) for minor, major, and total complications were calculated for each BMI category. The analysis was then repeated using wound-related complications (deep infection, superficial infection, and wound dehiscence) as the outcomes of interest.

Results: Of the 53,219 patients with a recorded BMI, 10.1% were underweight, 37.3% were of normal weight, 28.4% were overweight, 19.7% were obese, and 4.6% were morbidly obese. Compared with patients of normal weight, underweight patients had significantly greater odds of minor (OR 1.12, P = 0.04), major (OR 1.20, P <0.001), and total complications (OR 1.18, P <0.001). Morbidly obese patients had significantly greater odds of major (OR 1.22, P = 0.023) and total complications (OR 1.18, P = 0.023) than did patients of normal weight. Having a BMI in the overweight or obese range did not significantly increase the odds of minor, major, or total complications (Table 1). When wound-related complications were examined independently, compared with patients of normal weight, obesity was associated with increased odds of superficial (OR 1.67, P <0.0001) and deep wound infection (OR 1.52, P = 0.018), and morbid obesity was associated with increased odds of wound dehiscence (OR 2.29, P = 0.034) and deep infection (OR 2.51, P <0.0001). Trends toward increased odds of wound dehiscence in overweight (OR 1.72, P = 0.053) and obese (OR 1.71, P = 0.07) patients did not reach statistical significance.

Conclusion: BMI is a significant predictor of perioperative complications in orthopaedic trauma patients. Morbid obesity is associated with increased odds of major and total complications as well as wound-related complications including dehiscence and deep infection. In addition to identifying morbid obesity as a risk factor for perioperative complications, we demonstrate that a BMI less than 18.5 also places orthopaedic trauma patients at significantly higher risk for minor, major, and total complications, a finding not previously reported in the literature.

Table 1. Odds Ratios of Minor, Major, and Total Complications by BMI Category, as determined on multivariate analysis.

Complications	**Underweight** N=5369 (10.1%) (95% CI, p-value)	**Normal Weight** N=19831 (37.3%) (Reference)	**Overweight** N=15098 (28.4%) (95% CI, p-value)	**Obese** N=10467 (19.7%) (95% CI, p-value)	**Morbidly Obese** N=2454 (4.6%) (95% CI, p-value)
All Minor	**1.12** (1.01-1.26, p=0.04)	1	0.96 (0.87-1.05, p=0.32)	1.01 (0.91-1.12, p=0.87)	1.18 (0.98-1.43, p=0.077)
Wound Dehiscence	0.69 (0.24-2.02, p =0.50)	1	1.72 (0.99-2.98, p= 0.054)	1.71 (0.96-3.06, p= 0.07)	**2.29** (1.07-4.92, p= 0.034)
Superficial Wound Infection	0.96 (0.66-1.38,p= 0.82)	1	1.09 (0.85-1.40, p=0.48)	**1.67** (1.30-2.15, p<0.0001)	1.37 (0.89-2.11, p=0.15)
All Major	**1.20** (1.08-1.33, p<0.001)	1	**0.88** (0.81-0.96, p=0.004)	0.90 (0.81-1.00, p=0.053)	**1.22** (1.02-1.46, p=0.023)
Deep Wound Infection	0.96 (0.58-1.58, p=0.87)	1	1.01 (0.71-1.44, p=0.95)	**1.52** (1.08-2.14, p=0.018)	**2.51** (1.60-3.93, p<0.0001)
Total	**1.18** (1.08-1.28, p<0.001)	1	**0.90** (0.84-0.96, p=0.002)	0.94 (0.867-1.026, p=0.17)	**1.18** (1.02-1.37, p=0.023)

POSTER ABSTRACTS

See pages 47 - 108 for financial disclosure information.

Preoperative Labs: Wasted Dollars or Predictors of Postoperative Cardiac and Septic Events in Orthopaedic Trauma Patients?

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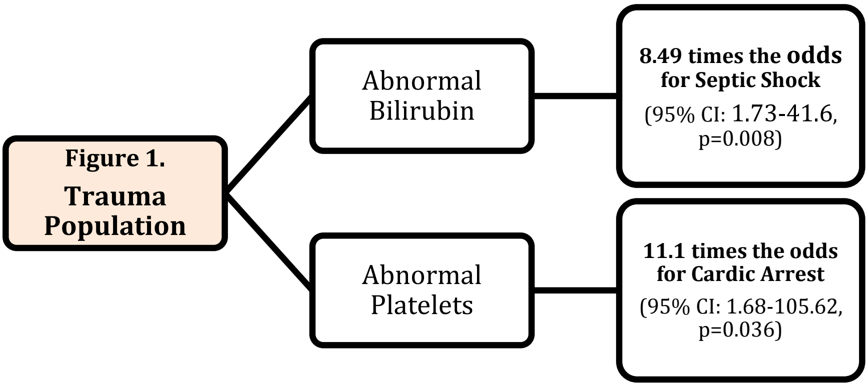
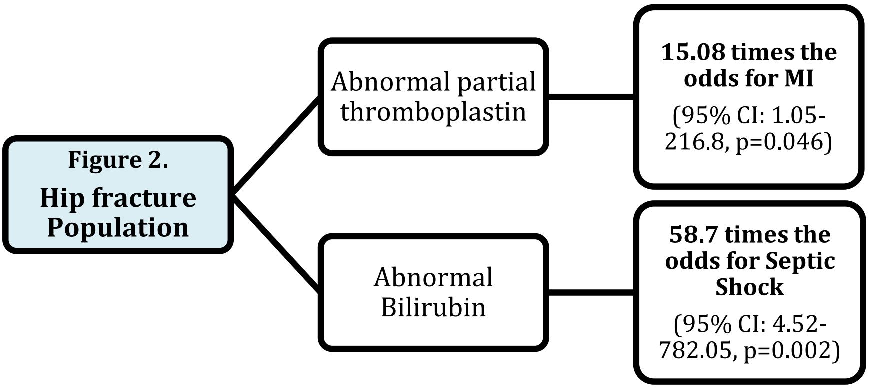
Background/Purpose: As US health-care expenditures continue to rise, avenues to reduce costs must be explored. Studies have estimated that over 70% of routine labs may be unnecessary, adding over $250 per patient per day in hospitals. For orthopaedic trauma patients, very little data exist in the utility of preoperative labs in predicting postoperative adverse events. In this study, we used the large, multicenter, prospective American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database to determine whether preoperative labs significantly predict postoperative cardiac and septic complications in orthopaedic trauma and hip fracture patients.

Methods: From 2005-2013, 361,402 patients were identified in the NSQIP database using Current Procedural Terminology (CPT) codes. Of these, 56,336 (15.6%) patients were identified as orthopaedic trauma and 27,441 patients (7.6%) were identified with hip fractures. Preoperative labs included sodium (normal: 135-145 mEq/L), BUN (blood urea nitrogen; normal: 7-20 mg/dL), creatinine (normal: 0.5-1.2 mg/dL), albumin (3.4-5.4 g/dL), bilirubin (normal: 0.3-1.9 mg/dL), SGOT (serum glutamic oxaloacetic transaminase; 10-34 IU/L), alkaline phosphatase (44-147 IU/L), white count (4.5-10K/mcL), hematocrit (38%-54%), platelet count (150-400 K/mcL), prothrombin time (11-13.5 seconds), INR (international normalized ratio; 0.8-1.1), and partial thromboplastin time (25-35 seconds). For each of these labs, patients were deemed to have normal or abnormal values. Patients were noted to have developed cardiac or septic complications if within 30 days after surgery they sustained (1) myocardial infarction (MI) (2) cardiac arrest, or (3) septic shock. Separate regressions with patient characteristics including age, gender, and preoperative comorbidities labs were run for orthopaedic trauma patients to determine whether preoperative labs predicted cardiac or septic outcomes. Only patients with complete data were included in the regressions.

Results: For all orthopaedic trauma patients, 1.3% (749/56,336) developed cardiac complications and 0.6% (311/56,336) developed septic shock. 2.2% (541/27,441) of hip fracture patients sustained cardiac events and 0.9% (322/27,441) developed septic shock. After multivariate regression, abnormal preoperative platelet values (odds ratio [OR]: 11.107, P = 0.036) were significantly predictive of postoperative cardiac arrest, and abnormal bilirubin levels (OR: 8.487, P = 0.008) were predictive of septic shock in trauma patients (Figure 1). For hip fracture patients, abnormal partial thromboplastin time (OR: 15.083, P = 0.046) was significantly associated with postoperative myocardial infarction, and abnormal bilirubin (OR: 58.674, P = 0.002) significantly predictive septic shock (Figure 2).

Conclusion: This study is the first of its kind to demonstrate the utility of preoperative labs in orthopaedic trauma and hip fracture patients in predicting cardiac and septic adverse events. Particular attention should be made to hematologic labs (platelets, partial thromboplastin) and bilirubin values.





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Are 2.7-mm Recon Plates Stable Enough for Anteroinferior Plating of Displaced Midshaft Clavicle Fractures?

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Purpose: Clavicular fractures comprise about 5% to 10% of all fractures, with 69% to 76% occurring in the middle third. Recent studies have shown that anteroinferior plating results in efficient healing, few complications, and excellent return to function. Because the anteroinferior plate is perpendicular to the primary force vector and has greater resistance to axial compression of the clavicle during motion, smaller plates (2.7 mm) could be used. The purpose of this study was to elucidate the rate of implant failure comparing 2.7-mm DC (dynamic compression) plates compared to 2.7 mm recon (reconstruction) plates for anteroinferior plating in midshaft clavicle fractures.

Methods: Between 2002 and 2010, 180 consecutive skeletally mature patients with 181 midshaft clavicle fractures underwent open reduction and internal plate fixation in one Level I trauma center, were followed in a single private practice, and retrospectively evaluated. Excluded patients were related to pathological fracture (1), death (1), initial nonoperative treatment (1), superior plating (8), and incomplete data (20). Therefore, the final study group consisted of 150 clavicle fractures in 149 patients. The distribution between the two plate types was almost equal: 80 DC plates (53.3%) and 70 recon plates (46.7%). Fractures were classified according to the AO/OTA classification. Patients were evaluated clinically and radiographically at regular intervals of 2, 6, and 12 weeks.

Results: The majority (67.1%) of the patients were male. Mean age was 41 years. The body mass index (BMI) averaged 26.3 kg/m2. Mean follow-up was 9.5 months (range, 3-54). Fractures were classified as 15B1 70 (46.7%), 15B2 62 (41.3%), and 15B3 17 (11.3%). Median plate length was 12 holes (range, 5-16). Median number of screws inserted was 8 (range, 4-12). Lag screws were used in 80 (53.3%). Average working length was 1.5 holes. Fractures healed in 97.3%. No infections were recorded. Four patients developed a nonunion (2.7%) and 3 fractures (2.0%) healed as malunions. Malunion formation was related to higher BMI ($P = 0.008$). No differences were found for nonunion or malunion regarding plate type, plate length, or working length. Hardware failure occurred in 6 fractures (4.0%). Failure rate was 7.1% in recon plate constructs (5 of 70) and 1.3% in DC plates (1 of 80) ($P = 0.066$).

Conclusion: Hardware failure in anteroinferior plating is low. Nonunion and hardware failure rates are low when following modern surgical techniques with longer plates. The increased rate of hardware failure led us to a recent change in surgical technique avoiding recon plates for clavicle osteosynthesis. Further biomechanical studies are warranted.

Severity Weighting of Adverse Events in Orthopaedic Trauma Surgery

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Background/Purpose: There has been a recent increase in the use of national databases to study the occurrence of adverse events following orthopaedic trauma surgery. Most of this research uses composite adverse event outcomes such as occurrence of "any adverse events," which treat adverse events with different clinical significances (for example, death and urinary tract infection) similarly. The failure to differentiate between these adverse events in terms of their clinical significance detracts from the clinical applicability of these studies' conclusions. The purpose of the present study is to address this shortcoming in research methodology through the creation of a single, severity-weighted outcome that can be used to determine the overall "severity" of any given patient's postoperative course.

Methods: Orthopaedic faculty at two academic institutions were invited to complete a severity-weighting exercise in which they were asked to consider how many of specific adverse events they would equate to the death of one patient. Their responses were used to generate a severity-weighting scheme called the "severity-weighted outcome relative to death," or SWORD. In the SWORD, patients with no adverse event are assigned 0%, patients with postoperative death are assigned 100%, and patients with other adverse events are assigned percentages in between (determined from the participants' responses). The SWORD was then applied. Patients undergoing eight common orthopaedic surgeries were identified in the 2012 American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database. First, mean SWORD was compared by procedure with adjustment for demographic and comorbidity characteristics. Second, patients undergoing the procedure with the highest mean SWORD (hip fracture surgery) were examined in depth. Among only these patients, mean SWORD was tested for association with age, sex, and six commonly studied comorbidities.

Results: At institution A, 23/23 faculty members (100%) completed the exercise, while at institution B, 24/27 faculty members (89%) completed the exercise, leading to an overall number of participants of 47 and an overall response rate of 94%. Mean severity weights generated from participant responses are provided in Figure 1. The weights ranged from 0.23% for urinary tract infection (least severe) to 15.14% for coma (most severe). A total of 85,031 patients from the 2012 NSQIP met inclusion criteria for the demonstration portion of the study. Mean SWORD ranged from 0.2% among patients undergoing elective anterior cervical decompression and fusion (procedure with the lowest mean SWORD) to 6.0% among patients undergoing hip fracture surgery (procedure with the highest mean SWORD; $P < 0.001$). Among patients undergoing hip fracture surgery, mean SWORD was independently associated with age, sex, and 4 of 6 tested comorbidities ($P < 0.05$ for each).

Conclusion: We present here the "severity-weighted outcome relative to death," or SWORD, a single, severity-weighted outcome that can be used to characterize the severity of any

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given orthopaedic trauma patient's postoperative course. The SWORD is designed to be used in future orthopaedic trauma database studies as a primary outcome that is more clinically meaningful than the composite outcomes that currently dominate the literature. The SWORD was highly associated with procedure type, demographics, and comorbidities. Taken together, these results demonstrate the manner in which the SWORD is intended to be used in future studies: to compare the severity-weighted outcome by demographic, comorbidity, and procedural characteristics to understand what are and are not risk factors for a problematic postoperative course. Future studies in orthopaedic trauma may benefit from use of the severity-weighted outcome score presented here. Other fields with growth in database research may consider using similar methods to create severity-weighting systems of their own.

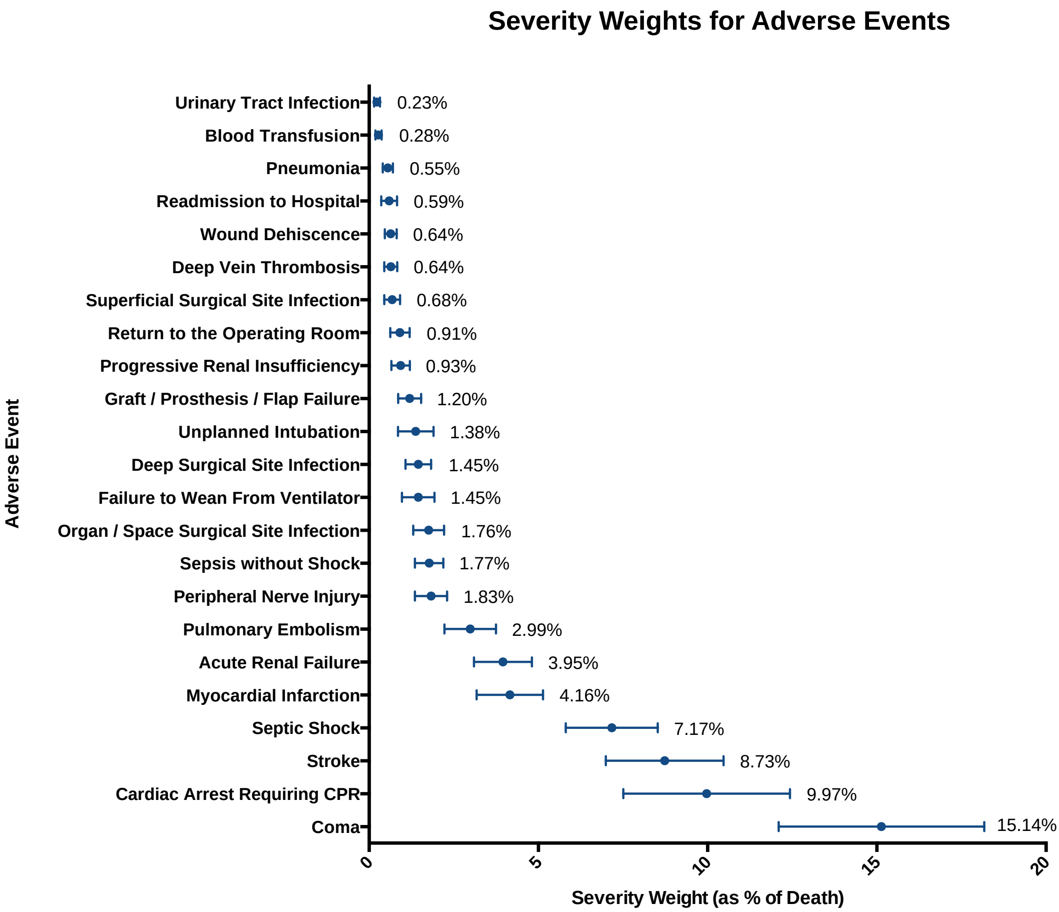

Figure 1

Figure 1. Severity weights for adverse events. Error bars indicate standard errors.

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.

Compartment Syndrome Training Assessment and Education Tool

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Background/Purpose: Assessing technical and motor skills is becoming an increasingly important component of orthopaedic resident education. Assessment methods, however, are underreported. In general surgery, residents' surgical and technical skills are evaluated using the Objective Structured Assessment of Technical Skills (OSATS) and Global Rating Scale (GRS). To our knowledge, no such assessment tool has been validated in assessment of orthopaedic resident surgical training. The purpose of this study was to utilize multiple methods of assessing orthopaedic surgical competency (knowledge test, OSATS, GRS, and task-specific surgical approach pass/fail assessment) and determine the reliability of these assessment tools applied to the lower limb compartment syndrome release. We hypothesized that these methods of evaluation would be a reliable means of evaluating orthopaedic residents' surgical skills for this specific procedure.

Methods: 20 residents spanning 5 years of surgical training (5 postgraduate year (PGY)-1, 5 PGY-2, 3 PGY-3, 3 PGY-4, and 4 PGY-5) were tested for their knowledge base and technical skill pertaining to compartment syndrome release. First residents took an electronic knowledge test and were then evaluated independently by three board-certified orthopaedic surgeons. Evaluation tools included OSATS with a detailed checklist score, GRS, and final task-specific pass/fail assessment. Time to completion was recorded. Each resident demonstrated intracompartmental pressure monitoring on an electronic lower extremity model, with a separate OSATS checklist and GRS. We hypothesized that these methods of assessment would provide an objective method of evaluating surgical skill and procedural competency applied specifically to compartment syndrome fasciotomies.

Results: Checklist scores varied significantly based on PGY in training on both the anterior-lateral ("lateral") ($F = 4.29$, $P = 0.005$) and superficial-deep ("medial") ($F = 5.35$, $P = 0.001$) fasciotomies, but no significant difference was seen by PGY in compartment measurements on the electronic lower leg model. Subjective pass/fail also varied by PGY for the lateral ($\chi 2 = 20.21$, $P = 0.01$) and medial ($\chi 2 = 15.82$, $P = 0.003$) approaches. PGY significantly influenced GRS score ($F = 9.6$, $P <0.001$). Junior trainees (PGY-1 to PGY-3) scored significantly lower than senior residents (PGY-4 and PGY-5) on the lateral ($P = 0.048$) and medial ($P = 0.018$) approach checklists as well as GRS score ($P = 0.001$). No significant differences in time required, knowledge test scores, or number of adverse events were observed between training years. Inter-rater reliability (IRR) for the lateral approach was 0.64, with 79% pass/fail agreement. IRR for the medial approach was 0.62 with 79% pass/fail agreement. GRS inter-rater reliability was 0.86.

Conclusion: Residency programs across the nation have long been tasked with training the next generation of orthopaedic surgeons. However, with the heightened focus on competencies and necessary milestones implemented by the Accrediation Council for Graduate Medical Education, despite increasing restrictions on duty hours, the orthopaedic surgery

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community needs to develop standard assessment methods to ensure our residents achieve these goals, and do so in a stepwise and comparable manner throughout their training. Currently, only a few generalized methods of orthopaedic surgery resident evaluation exist. The need for more specific evaluation of resident technical and motor skills exists, and if done on a task specific basis can provide information on the technical level at which residents are, and identify areas in which they need improvement. This project allowed us the opportunity to investigate skill assessment tools which can be implemented at training programs across the nation.

Establishing Radiographic Guidelines in Postoperative Care of Lower Extremity Fractures

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Introduction: Studies are beginning to question the usefulness of routine radiographs obtained early in the postoperative course following fracture fixation. The goal of this study was to investigate the cost-effectiveness and clinical utility of radiographs at all time points following internal fixation of lower extremity fractures.

Methods: A retrospective chart review was conducted at a level I trauma center. Four hundred eighty-five (485) patients with 586 operatively treated lower extremity fractures were included. These fractures represented all AO/OTA classification codes for the femur and tibia. Variables related to patient demographics, fracture characteristics, clinical management and outcomes were collected. Data was analyzed to investigate the impact of radiographs on changes in management at all follow-up clinic visits for each type of fracture.

Results: Each fracture received, on average, 4.8 radiographs following fixation for a total cost of $747,496. The management of 30.7% of fractures deviated from the expected postoperative course. The most common changes in management were return to the operating room (36%), workup or treatment for infection (21%), and prolonged weight bearing restriction (18%). These changes were most frequently made based on history and physical exam (H&P) findings alone (47%). Thirty-one percent (31%) of changes were due to radiographic findings alone and these changes occurred at very specific time intervals: 1) in the immediate post-operative period (0.5% of changes) and 2) in the period from consideration of advancement to full weight bearing up until confirmation of fracture union (30.2%). Radiographs obtained between the immediate postoperative period and the weight bearing as tolerated visit did not lead to any changes in management in the absence of positive findings on history and physical exam. Similarly, films obtained after confirmation of union did not lead to changes in management. If non-clinically indicated imaging was eliminated in our cohort, 38% of radiographs could have been eliminated without any changes in clinical outcome. This would have resulted in a cost savings of approximately $350,000. Using these findings, we developed a postoperative radiographic guideline for lower extremity fractures with emphasis on optimal timing for clinical decision-making and the importance of clinical indications. Application of this guideline to operatively treated lower extremity fractures from a single year ins the Healthcare Cost and Utilization Project's National Inpatient Sample database would have led to a potential national cost savings of over $350 million.

Conclusions: Radiographs obtained following operative treatment of lower extremity fractures contribute to changes in patient management in the absence of clinical indications 1) in the immediate postoperative period in select cases where intraoperative fluoroscopy may be inadequate, and 2) during the period when advancement to full weight bearing is considered up until confirmation of fracture union. Imaging in the absence of clinical indications may be eliminated 1) in the period prior to consideration of advancement to full weight bearing and 2) after confirmation of fracture union. This study presents evidence-based recommendations for improving the cost-effectiveness of postoperative radiographic utilization when treating lower extremity fractures.

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Risk Factors for Deep Venous Thrombosis in Orthopaedic Trauma: An Analysis of 56,000 Patients

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Purpose: Deep venous thrombosis (DVT) and pulmonary embolism (PE) are recognized as major causes of morbidity and mortality in orthopaedic trauma patients. Despite the high incidence of these complications following orthopaedic trauma, there is a paucity of literature investigating the clinical risk factors for DVT in this population. As our health-care system increasingly emphasizes quality measures, it is critical for orthopaedic surgeons to understand the clinical factors that increase the risk of DVT following orthopaedic trauma. Utilizing the ACS NSQIP (American College of Surgeons National Surgical Quality Improvement Program) database, we sought to identify risk factors associated with the development of DVT in orthopaedic trauma patients.

Methods: A prospective cohort of 56,299 patients was identified from the 2006 to 2013 ACS NSQIP database using CPT codes for orthopaedic trauma procedures. Using Wilcoxon-Mann-Whitney and chi-square tests where appropriate, 49 variables including age, race, body mass index (BMI), American Society of Anesthesiologists (ASA) score, medical comorbidities, operative time, and anatomic region injured were compared between patients who developed a DVT within 30 days and those who did not. Using a multivariate logistic regression analysis, odds ratios (ORs) for DVT were determined for these 49 potential risk factors. Significance was set at $P < 0.05$.

Results: 56,299 orthopaedic trauma patients were included in the analysis, of whom 473 (0.84%) developed a DVT within 30 days. In univariate analysis, 25 of the 49 variables were significantly associated with the development of a DVT, including age ($P < 0.0001$), BMI ($P = 0.037$), diabetes ($P = 0.01$), ASA score ($P < 0.0001$), and anatomic region injured ($P < 0.0001$) (Table 1). As shown in Figure 1, multivariate analysis identified several risk factors that significantly increased the odds of developing a DVT. The use of a ventilator increased the odds of DVT by 43.67 times ($P = 0.039$) while ascites increased the risk of DVT 41.61 times ($P = 0.0038$). Compared to patients with upper extremity trauma, those with lower extremity injuries had 7.55 times (confidence interval [CI]: 1.78-32.04, $P = 0.006$) greater odds of developing a DVT within 30 days (Fig. 2). The trend toward greater odds of DVT among patients with injuries to the hip/pelvis did not reach statistical significance (odds ratio [OR] 4.51, CI: 0.39-52.50, $P = 0.22$). Smoking was not found to be an independent risk factor for developing a DVT ($P = 0.1217$).

Conclusion: This is the largest study to date aimed at identifying risk factors for DVT in orthopaedic trauma patients. Although the incidence of DVT was low in this cohort, the presence of certain risk factors significantly increased the odds of developing a DVT following orthopaedic trauma. These findings will enable orthopaedic surgeons to target at-risk patients and implement postoperative care protocols aimed at reducing the morbidity and mortality associated with DVT in orthopaedic trauma patients.

Table 1. Patient Demographics

	DVT (N= 473, 0.08%)	No DVT (N=55,826, 99.2%)	p-value
Age (mean)	79	72	0.0001
BMI (mean)	25.4	25.0	0.037
Diabetes	100 (21.1%)	8,931 (16.0%)	0.01
Location			0.0001
Upper extremity	30 (6.34%)	11,373 (20.4%)	
Lower extremity	433 (91.54%)	42,819 (76.7%)	
Hip/ pelvis	6 (1.3%)	762 (1.4%)	
ASA Status			0.0001
1	15 (3.17%)	5,423 (9.7%)	
2	101 (21.4%)	17,631 (31.6%)	
3	253 (53.5%)	26,070 (46.7%)	
4	104 (22.0%)	6,577 (11.8%)	

Figure 1. Odds Ratio for Risk Factors for a DVT

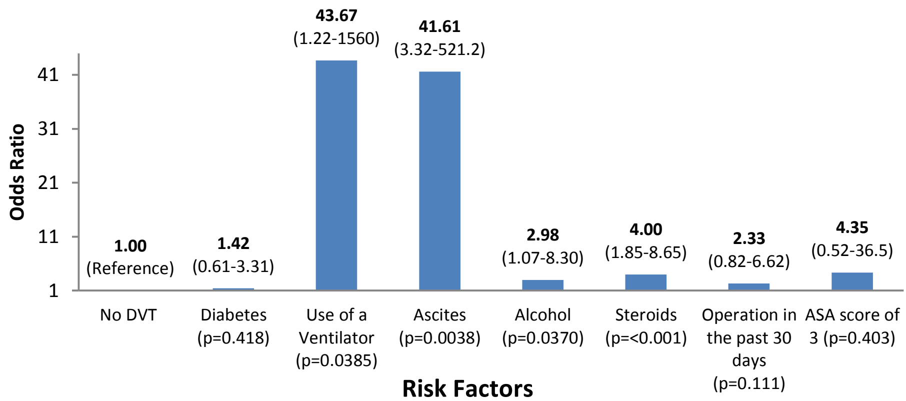
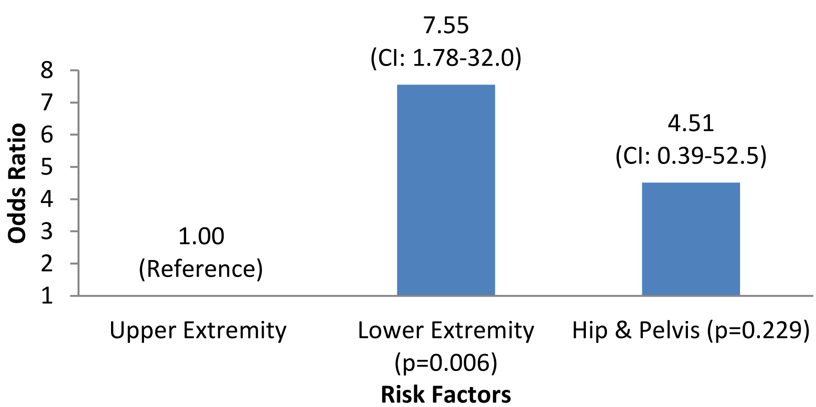


Figure 2. Odds Ratios for Risk Factors for a DVT: Anatomic Region



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Humeral Shaft Fractures Treated with Lag Screw Fixation Heal with Callus

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Purpose: Existing dogma states that fractures treated with anatomic reduction of fracture fragments and lag screw fixation will heal with primary bone healing and no fracture callus. Our observations lead us to question this dogma in the domain of humeral shaft fracture healing. Our hypothesis was that fractures treated with anatomic reduction and lag screw fixation with neutralization plating of the humeral diaphysis will heal without fracture callus.

Methods: We performed a retrospective chart and radiographic review of all humeral shaft fractures (OTA 1.12A-C) treated with open reduction and internal fixation at a Level I trauma center over 11 years (2003-2014). We included diaphyseal fractures treated with standard 4.5-mm or 3.5-mm plates (n = 153) as well as more proximal and distal periarticular diaphyseal fractures treated with precontoured specialty plates (n = 65). Our study group (n = 218) included only healed patients treated with lag screws and neutralization plating and did not include any patients with hardware failure. All images of healed fractures were reviewed on PACS (picture archiving and communication system) clinical software. Our primary outcome measure was the presence of healing through primary (no callus) or secondary (obvious callus) bone healing. Descriptive statistics were calculated and comparative tests used a two-sided Fisher exact test.

Results: Our data indicated that 99.1 (216/218, 95% confidence interval [CI] 97.8%-100%) healed fractures demonstrated callus at final healing. The rate of callus formation was similar in patients treated with 3.5-mm plates (98.9%) as well as 4.5-mm plates (100%, P = 1.00), despite the use of lag screws and attempt to achieve primary bone healing.

Conclusion: In contrast to existing dogma, primary bone healing was rarely observed despite the use of lag screw fixation. This is an important fact as existing teaching indicates that callus formation after attempts at primary bone healing is a sign that fixation or fracture healing may be failing. Clinicians should be aware that callus formation after plate and screw fixation with a goal of primary bone healing in the humerus is not typically a sign of impending failure and should in fact be routinely expected.

The REDUCTION Protocol: An Ultra Low-Dose CT Scan for Fracture Evaluation with an Improved Patient Safety Profile

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Purpose: The key diagnostic modalities for orthopaedic trauma include plain radiograph (XR) and/or computed tomography (CT) imaging when greater detail is needed. This study aims to evaluate whether the Reduced Effective Dose Using Computed Tomography In Orthopaedic iNjury (REDUCTION) protocol is sufficient to detect, diagnose, and guide treatment for various fracture types as compared to conventional CT (C-CT) scan.

Methods: The REDUCTION protocol was developed as a quality improvement/patient safety measure at our academic medical center. 11 patients receiving this protocol were matched for fracture location, classification, gender, and age to patients with C-CT scans. Nine fellowship-trained orthopaedic traumatologists and 1 chief orthopaedic resident representing 5 academic Level I trauma centers were blinded to a set of de-identified CT images. The studies were evaluated twice, 4 weeks apart to allow for adequate washout. The set of images consisted of a series of key cuts representing 8 different fracture types in 5 locations (4 foot, 2 knee, 2 ankle, 2 elbow, and 1 hip fracture) and 22 total studies of the extremities, comprised of mixed C-CT and ultra low-dose CT (REDUCTION) images. Outcome measures included correct diagnosis, management plan, weight-bearing status (WBS), and adequacy of image quality. Descriptive statistics were used to assess sensitivity (Sn), specificity (Sp), positive predictive value (PPV), and negative predictive value (NPV) for the ultra low-dose CT. Interobserver and intraobserver reliability (kappa [κ] statistics) were calculated among observers.

Results: Mean estimated effective dose (ED) for REDUCTION studies versus C-CT was 0.03 mSv versus 0.43 mSv. The Sn, Sp, PPV, and NPV of REDUCTION protocol to detect all fractures was 0.86, 0.80, 0.98, and 0.36, but increased to 0.98, 0.80, 0.98, and 0.80 with occult fractures excluded. Interobserver and intraobserver reliability for diagnosis utilizing REDUCTION protocol ($\kappa = 0.75$, $\kappa = 0.67$) yielded substantial agreement among observers compared to C-CT ($\kappa = 0.85$, $\kappa = 0.82$). Interobserver agreement for treatment, treatment modality, WBS, and study quality utilizing REDUCTION protocol was moderate to near perfect ($\kappa = 0.67$, $\kappa = 0.67$, $\kappa = 0.56$, $\kappa = 0.89$) as compared to C-CT ($\kappa = 0.84$, $\kappa = 0.84$, $\kappa = 0.78$, $\kappa = 0.68$). Intraobserver agreement for the same outcomes were substantial to near perfect ($\kappa = 0.82$, $\kappa = 0.82$, $\kappa = 0.82$, $\kappa = 0.64$) as compared to C-CT ($\kappa = 0.82$, $\kappa = 0.89$, $\kappa = 0.87$, $\kappa = 0.64$). There was wide discrepancy in identifying an occult femoral neck fracture ($\kappa = 0.2$) using REDUCTION protocol, with only 30% of observers correctly identifying this fracture.

Conclusion: A mean ED of .03 mSV was achieved with the REDUCTION protocol, a 14x reduction as compared to C-CT, and less than half the ED for a standard XR of the chest (.08 mSv). Reliability statistics between the REDUCTION protocol and C-CT were comparable across images, indicating that the REDUCTION protocol could be readily interpreted by orthopaedic traumatologists. Evaluation of occult fractures may warrant C-CT for better

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detail. Ultimately, the REDUCTION protocol appears to provide for high-fidelity images in appropriately selected patients.

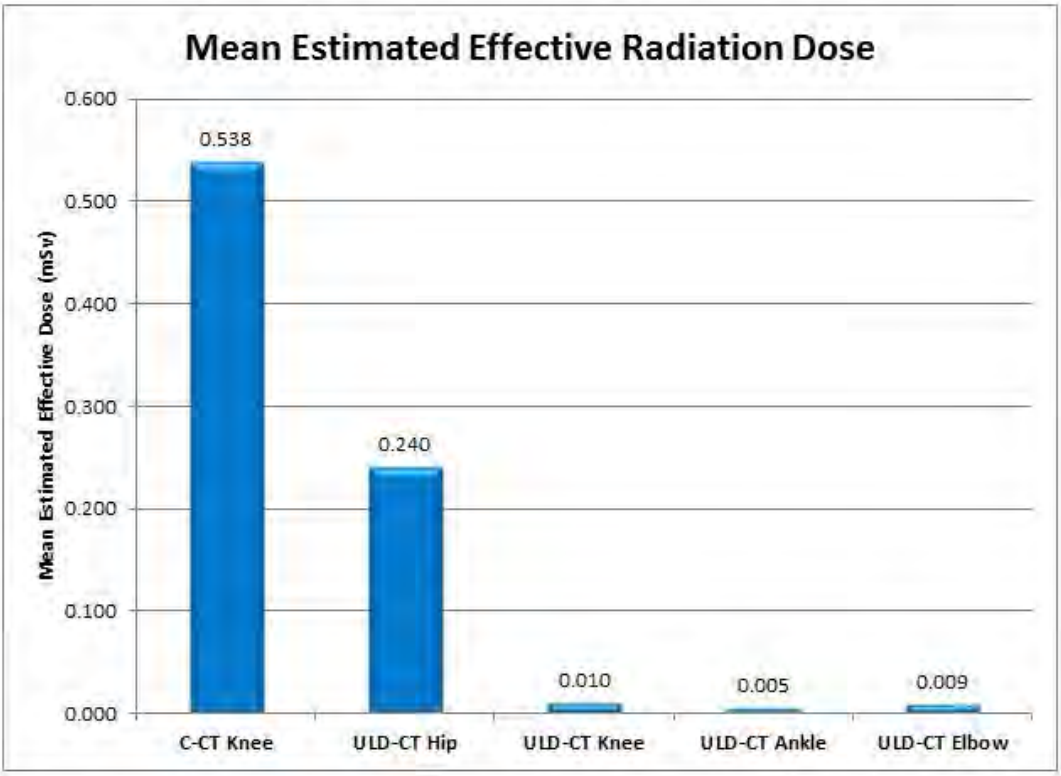

Figure 1. Effective radiation dosages for various extremity locations. C-CT= conventional CT scan; ULD-CT= ultra low dose CT scan

POSTER ABSTRACTS

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.

The REDUCTION Protocol Generates Three-Dimensional Reconstructed Images Comparable to Conventional CT

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Purpose: At our academic medical center, we have developed a Reduced Effective Dose Using Computed Tomography In Orthopaedic iNjury (REDUCTION) protocol that minimizes effective radiation dose while providing high-fidelity two-dimensional advanced imaging. We sought to evaluate the ability of this technology to generate advanced three-dimensional CT (3D-CT) imaging using this ultra low-dose CT protocol for assessment of various fracture types.

Methods: Using a 64-slice CT scanner (SOMATOM Sensation, Siemens), radiation dose was lowered from the standard radiation dose by altering multiple parameters: tube current (milliamperes, mA), tube potential (kilovolts, kV), detector collimation (mm), slice thickness (mm), reconstruction interval (mm), pitch, and gantry rotation time. Reconstructed 3D-CT images utilizing REDUCTION protocol for 4 different fracture locations (pelvis / acetabulum, tibial plateau, tibia / fibula, and elbow) were matched to reconstructed 3D-CT images utilizing conventional CT (C-CT). All images were de-identified prior to evaluation, and images were matched by fracture location, characterization, gender, and age. Three independent fellowship-trained orthopaedic traumatologists evaluated corresponding sets of REDUCTION protocol and conventional CT images. Evaluators were queried as to whether paired REDUCTION protocol and C-CT 3D-reconstructed images were equivalent in quality, and as to whether each scan afforded an equivalent amount of diagnostic information. Inter-rater reliability (kappa [κ] statistics) was calculated to assess for differences among respondents.

Results: The REDUCTION protocol utilized parameters as follows: tube current (15 mA), tube potential (80 kV) detector collimation (0.625), slice thickness (3 mm), reconstruction interval (3 mm), pitch (.516-1), and gantry rotation time (0.5). 3D-reconstructed CT images using REDUCTION protocol were rendered with an estimated effective dose (ED) of 0.08 mSv as compared to 0.8 mSv for 3D-CT images rendered using C-CT. Inter-rater reliability for equivalence in quality between REDUCTION protocol and C-CT rendered 3D images was near perfect ($\kappa = 0.87$). Inter-rater reliability as to equivalence of diagnostic information between REDUCTION protocol and C-CT rendered 3D images was near perfect ($\kappa = 0.94$).

Conclusion: The use of the REDUCTION protocol for diagnostic assessment of specific fractures of the extremities affords the ability to create high-resolution reconstructed 3D-CT images comparable to that rendered utilizing conventional CT. With approximately a tenfold reduction in irradiation to patients, this adapted modality may ultimately be able to redress optimal diagnostic imaging in appropriately selected patients.

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Figure 1. ULD-CT images (left) vs. corresponding C-CT images (right). Nearly indistinguishable resolution with ULD-CT and with a 10x decrease in effective radiation dose (equivalent to 1 chest radiograph).

Long-Term Implantation of Polymethylmethacrylate Antibiotic Beads at a Fracture Site

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Purpose: Polymethylmethacrylate (PMMA) antibiotic beads can be an effective treatment for open fractures and chronic osteomyelitis. High drug concentrations can be delivered locally without having systemic effects with an additional benefit of not requiring patient compliance. It is not clear whether the beads cause long-term adverse events if not removed. There are risks with performing an additional operation to remove the beads. The aim of this study was to determine if removal of antibiotic beads was required to avoid long-term complications.

Methods: A retrospective chart review at a Level I regional trauma center was conducted on patients with an extremity or pelvis fracture that had implantation of PMMA antibiotic beads from 2008-2013. The PMMA beads were pre-made by pharmacy, containing vancomycin, tobramycin, or both antibiotics. Exclusion criteria include age less than 18 years, patients treated in staged surgical manner, follow-up less than 6 weeks, and spine cases. The orthopaedic outpatient notes were reviewed for the clinical evidence of infection or painful beads based on history or examination. On those patients who underwent removal, the surgical reports and the intraoperative culture data were reviewed.

Results: 370 patients had PMMA antibiotic beads placed by an orthopaedic surgeon at our institution from 2008-2013. 49 patients met criteria for our study; the majority were excluded for planned staged surgical management. Average follow-up was 35 weeks (range,6-269 weeks). 31 patients (63%) did not undergo bead removal and there were no wound complications at long-term follow-up. 17 patients (34%) underwent unplanned surgical bead removal. 11 of those patients (22%) had delayed wound healing and removal within 90 days of placement during repeat surgical debridement. Four patients (8%) had complete wound healing, but had removal during fracture nonunion repair or total joint arthroplasty. In patients with complete wound healing prior to removal, there was no purulence found intraoperatively during PMMA bead removal and intraoperative cultures were negative. Two patients (4%) had removal because of PMMA bead protuberance in areas of thin subcutaneous tissue causing pain. No patients developed antibiotic resistance, although three patients had new bacteria identified on repeat cultures.

Conclusion: PMMA antibiotic beads can be utilized in musculoskeletal infections and do not need to be removed in all patients. Patients who had complete wound healing after placement of beads, did not have repeat surgical debridement for wound complications. PMMA beads do not necessarily harbor an environment for infection or promote antibiotic resistance. However, the PMMA beads may need to be removed during repeat surgical debridement for delayed wound healing or in areas of thin subcutaneous tissue.

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When Are CT Angiograms Indicated for Lower Extremity Fractures?

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Background/Purpose: Computed tomography angiography (CTA) has become a frequently used imaging modality for the detection of traumatic vascular injuries. Although there is evidence to guide the utilization of imaging modalities when "hard signs" of vascular injury are present, there are no guidelines for their use when only "soft signs" or "no signs" of vascular injury are present in the setting of an acute lower extremity injury. The purpose of this study was to review the CTAs performed at our institution and determine: (1) the presence or absence of any signs of a vascular injury; (2) which, if any, soft and/or hard signs were predictors of positive CTA findings and/or the need for treatment of the detected vascular injury; and (3) what type(s) of lower extremity fractures (open and closed) and injury mechanism(s), if any, were associated with a positive CTA findings and/or the need for treatment. Methodss: A retrospective review was conducted on 275 consecutive patients treated at a Level I trauma center from 2004-2013 who had an acute lower extremity fractures and a CTA. Their charts were reviewed for the presence or absence of the five hard signs (absent distal pulse, pulsatile bleeding, expanding hematoma, cold/pale limb, palpable thrill, audible bruit) and the five soft signs (decreased pulse, peripheral nerve deficit, small hemorrhage, wound near artery, nonpulsatile hematoma) of a vascular injury and were recorded. Each fracture was classified using the OTA classification and the status of soft tissue (open vs closed) and mechanism of injury was recorded. Every CTA radiology report was reviewed and was considered positive if there was any concern for injury to a specific vessel. Any vascular intervention or need for an amputation due to a vascular injury was recorded.

Results: 275 extremities' CTAs were reviewed and 80 (29%) reports had positive findings of a vascular injury. Only 16 (6%) of those extremities required treatment. 108 extremities had no documented soft or hard signs and none of those had a positive CTA. Extremities that had more than one hard or soft sign had an increased chance of a positive CTA finding (Table 1). When an extremity had at least one hard or soft sign, the presence of "open" soft-tissue injury and/or an injury located distal to the knee injuries increased the chances of having a positive CTA finding and an intervention for that vascular injury (Table 2). Injuries caused by a high-energy mechanism accounted for 99% of positive CTA findings but there was no difference between the specific types of high energy mechanism (Table 2). The 16 cases that required treatment of a vascular injury all had diminished or absent pulses on presentation to the emergency department and 13 of 16 had an "open" injury.

Conclusion: Based on our findings there is no evidence to support the routine use of CTAs for lower extremity fractures unless soft or hard signs of a vascular injury are present on physical examination. The presence of: (1) an open injury, (2) an injury located distal to the knee, and (3) a high-energy mechanism of injury had a higher risk of a vascular injury. However, only 6% of the cases that had positive CTA required a change in their treatment and all of those cases had either diminished or absent distal pulses present on physical examination.

Table 1. Correlation of physical exam findings, positive CTA results, and the need for vascular treatment

Physical Exam Findings	# of CTAs	# (%) of positive CTAs	# (%) requiring treatment
No soft or hard sign	108	0 (0%)	0 (0%)
One soft sign	73	29 (40%)	2 (3%)
Two soft signs	4	3 (75%)	0 (0%)
One hard sign	43	18 (42%)	4 (9%)
Two hard signs	16	11 (69%)	4 (25%)
Combinations of hard and soft signs	30	19 (63%)	6 (20%)

Table 2. The effect of fracture location, soft tissue status and mechanism of injury on CTA results.

	# of CTAs	# of positive CTAs	% positive CTAs	# requiring treatment	% requiring treatment
FRACTURE LOCATION					
Proximal femur	7	0	0%	0	0%
Midshaft Femur	5	2	40%	0	0%
Distal Femur	1	0	0%	0	0%
Proximal tibia +/- fibula	35	10	29%	2	6%
Isolated proximal fibula	8	5	63%	3	38%
Isolated midshaft fibula	2	2	100%	0	0%
Midshaft tibia +/- fibula	50	26	52%	4	8%
Distal tibia +/- fibula	8	6	75%	0	0%
Foot fractures	3	2	67%	1	33%
Multiple fractures	47	28	60%	6	13%
INJURY MECHANISM					
Gunshot Wound	23	12	52%	4	17%
Motor vehicle collision	34	18	53%	6	18%
Motor Cycle Collision	34	15	44%	1	3%
Fall from Height	12	5	42%	0	0%
Ground Level Fall	7	1	14%	0	0%
Auto versus pedestrian	48	26	54%	4	8%
Blast Injury	3	0	0%	0	0%
Crush Injury	3	2	67%	1	33%
SOFT TISSUE STATUS					
Open Injuries	96	58	60%	13	14%
Closed Injuries	70	22	31%	3	4%

All data included in this table is from patients who had at least one hard or soft sign on physical exam since no patient without at least one sign had a positive CTA

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Wide Variation of Surgical Cost Between 6 Fellowship-Trained Trauma Surgeons in the Treatment of Periarticular Lower Extremity Injuries

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Background/Purpose: Improving health care value is of increasing importance in today's challenging economic environment. Variation in procedural patterns among surgeons may be a significant contributor to direct surgical costs. We have hypothesized that despite similar subspecialty training there would be a high variation in direct surgical cost between surgeons in the treatment of bimalleolar ankle and bicondylar tibial plateau fractures. Identification of high-cost items and their critical evaluation would allow for substantial cost savings in the future.

Methods: We developed a novel software tool called a "seismograph," which allowed us to analyze detailed invoice costs of individual surgical procedures. We isolated cases from a single Level I trauma center over a 2-year period using a CPT code search for open treatment of bimalleolar ankle fractures and bicondylar tibial plateau fractures. We excluded cases with more than one procedure occurring in that setting. All costs associated with each procedure such as implants, drapes, disposables, and equipment were identified. Only the definitive procedures were analyzed; if performed, temporary external fixation of fractures was not included in the analysis in order to avoid bias. Macroscopically, the seismograph provided a bird's-eye view of all costs, which highlighted case and surgeon differences and patterns. We then analyzed the data descriptively (means and medians) and compared the direct surgical costs between surgeons using a one-way analysis of variance (ANOVA) after confirming the normal distribution of the available data using the Kolmogorov-Smirnov test.

Results: We identified 134 cases meeting our inclusion/exclusion criteria. The total direct surgical cost for the treatment of 88 bimalleolar ankle fractures was $96,866 and the total cost for the treatment of 46 bicondylar tibial plateau fractures was $148,066. There was a wide variation in direct surgical costs for both injuries between surgeons. The overall mean cost in the treatment of a bimalleolar ankle fracture was $1099, ranging from $613 (mean value per case for the least expensive surgeon) to $2243 (mean value per case for the most expensive surgeon). This difference was statistically significant (P = 0.009). However, the median cost, which is a measure that describes 50% of the cases being more expensive and 50% of the cases being less expensive, had a fairly tight range between $598 and $784 for the six evaluated surgeons, indicating that the most expensive cases significantly contributed to the overall cost. The most expensive 25% of the cases resulted in 57% of the overall cost, which was $55,616 compared to $41,250 for the remaining 75% of the cases. The overall mean cost in the treatment of a bicondylar tibial plateau fracture was $3219, ranging from $1839 (mean value per case for the least expensive surgeon) to $4088 (mean value per case for the most expensive surgeon) (P = 0.064). The range for the median cost between the six surgeons was substantially wider (Fig. 1) than for ankle fractures with $1826 for the least expensive surgeon and $3989 for the most expensive surgeon indicating a wide range of surgical treatment patterns between surgeons for a typical case (median). High-price items that substantially raised the mean cost were bone void fillers (calcium phosphate cement and allograft cancellous bone graft), adjunctive external fixators, locking plates, adjunctive mini-fragment locking plates used as either temporary or definitive reduction aids, as well as disposable and single-use items such as taps, company-specific guidewires, cannulated screws, drill bits, certain sutures, and expensive drapes.

Conclusion: This study demonstrated a wide variation in direct surgical cost in the treatment of bimalleolar ankle fractures and bicondylar tibial plateau fractures between six surgeons at the same Level I trauma center. We identified high-price items, some of which can be easily avoided, and some of which should be evaluated for their contribution to patient outcomes in future clinical studies. The use of the "seismograph" tool bears an enormous potential for cost savings as it can be used to critically analyze the cost of other surgical procedures within and outside of orthopaedics.

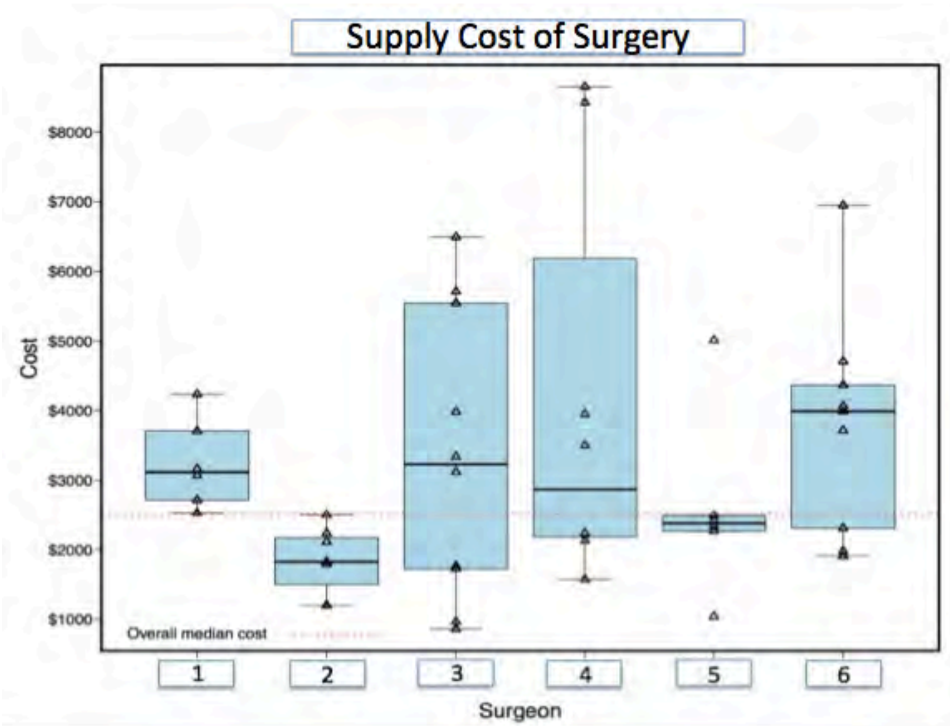

Figure 1: Graphic presentation of cost variation between 6 surgeons. Solid lines represent the median value. The boxes represent the interquartile (25%-75%) range, and the width of the boxes demonstrates variation in cost. A wider interquartile box conveys more variation.

See pages 47 - 108 for financial disclosure information.

Hip and Pelvic Fracture Patients Incur Significantly Different Inpatient Costs, Despite Being Reimbursed Under the Same Medicare Diagnosis-Related Group

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Background/Purpose: The current Medicare Acute Inpatient Prospective Payment System (PPS) determines reimbursement for inpatient admissions by categorizing patients into 746 Diagnosis-Related Groups (DRGs). All inpatient admissions under the same DRG are reimbursed with the same prospective, "bundled" payment, regardless of actual hospital costs. Under the current system, DRG 536 (fractures of the hip and pelvis) includes a broad spectrum of orthopaedic trauma patients with varying inpatient costs. Our aim is to evaluate differences in hospital resource utilization between four subgroups of DRG 536: acetabulum fractures, other pelvic fractures, pertrochanteric hip fractures, and transcervical hip fractures.

Methods: All patients with hip or pelvic fractures who are above the Medicare age cutoff (65 years) were identified in the 2011 and 2012 National Trauma Data Bank (NTDB). Patients were grouped into the following subgroups: acetabulum fractures, other pelvic fractures, pertrochanteric hip fractures, and transcervical hip fractures. Total inpatient length of stay, intensive care unit (ICU) stay, and ventilator time was compared across groups using multivariate analysis, controlling for preexisting comorbidities and age (Charlson Comorbidity Index [CCI]), injury severity (ISS), and hospital size (American College of Surgeons [ACS] trauma level).

Results: A total of 56,683 patients meeting inclusion criteria were identified. Of those, 6579 patients had acetabulum fractures, 15,125 had other pelvic fractures, 25,330 had pertrochanteric hip fractures, and 9649 had transcervical hip fractures. Mean length of stay was 8.5 days, 6.7 days, 6.7 days, and 6.4 days for the four previously stated groups, respectively ($P < 0.001$). Mean ICU stay was 2.8 days, 1.7 days, 0.7 days, and 0.6 days for the four groups, respectively ($P < 0.001$). Mean ventilator time was 1.5 days, 0.9 days, 0.3 days, and 0.2 days for the four groups, respectively ($P < 0.001$). In multivariate analysis (Table), after controlling for CCI, ISS, and ACS level, these differences remained significant. Compared to acetabulum fractures, other pelvic fractures were associated with 1.7 fewer days in the hospital (95% confidence interval [CI]: 1.4-1.9 days), 0.9 fewer days in the ICU (0.8-1.1 days), and 0.5 fewer days on the ventilator (0.4-0.6 days). Pertrochanteric hip fractures were associated with 1.4 fewer days in the hospital (95% CI: 1.2-1.6 days), 1.7 fewer days in the ICU (1.6-1.9 days), and 1.0 fewer days on the ventilator (0.9-1.1 days), compared to acetabulum fractures. Transcervical hip fractures were associated with 1.6 fewer days in the hospital (95% CI: 1.3-1.8 days), 1.8 fewer days in the ICU (1.6-1.9 days), and 1.0 fewer days on the ventilator (0.9-1.1 days), compared to acetabulum fractures. As expected, increasing CCI, ISS, and ACS level (up to Level I) were also associated with increased resource utilization.

Conclusion: Even after controlling for patient age, comorbidities, overall injury severity, and hospital ACS level, there with significant differences in hospital resource utilization between the four subgroups of Medicare DRG 536. As hospitals are reimbursed the same for these admissions, outside of a single reimbursement modifier for any and all complications and comorbidities, these findings suggest either underreimbursement of higher cost patients (acetabulum fractures) or wasted Medicare payment on lower cost patients (hip fractures). While true health-care cost figures are difficult to estimate, the current analysis circumvents this, showing clear differences in resource utilization and a need for reevaluation of orthopaedic DRGs in the Medicare Prospective Payment System.

Table 1: Multivariate analysis of length of stay

Outcome: Length of stay (days)	Average length of stay	Multivariate regression coefficient (95% confidence interval)	*P*-value
Acetabulum fracture	8.5 days	reference	-
Other pelvic fracture	6.7 days	-1.7 days (-1.9 to -1.4 days)	< 0.001
Pertrochanteric hip fracture	6.7 days	-1.4 days (-1.6 to -1.2 days)	< 0.001
Transcervical hip fracture	6.4 days	-1.6 days (-1.8 to -1.3 days)	< 0.001
Charlson Comorbidity Index	-	+ 0.2 days (0.2 to 0.3 days)	< 0.001
Injury Severity Score	-	+ 0.2 days (0.2 to 0.2 days)	< 0.001
Hospital ACS level	-	+ 0.8 days (0.7 to 0.9 days)	< 0.001

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Table 2: Multivariate analysis of ICU stay

Outcome: ICU Stay (days)	Average ICU stay	Multivariate regression coefficient (95% confidence interval)	*P*-value
Acetabulum fracture	2.8 days	reference	-
Other pelvic fracture	1.7 days	-0.9 days (-1.1 to -0.8 days)	< 0.001
Pertrochanteric hip fracture	0.7 days	-1.7 days (-1.9 to -1.6 days)	< 0.001
Transcervical hip fracture	0.6 days	-1.8 days (-1.9 to -1.6 days)	< 0.001
Charlson Comorbidity Index	-	+ 0.1 days (0.0 to 0.1 days)	< 0.001
Injury Severity Score	-	+ 0.2 days (0.2 to 0.2 days)	< 0.001
Hospital ACS level	-	+ 0.3 days (0.2 to 0.4 days)	< 0.001

Table 3: Multivariate analysis of ventilator time

Outcome: Ventilator time (days)	Average ventilator time	Multivariate regression coefficient (95% confidence interval)	*P*-value
Acetabulum fracture	1.5 days	reference	-
Other pelvic fracture	0.9 days	-0.5 days (-0.6 to -0.4 days)	< 0.001
Pertrochanteric hip fracture	0.3 days	-1.0 days (-1.1 to -0.9 days)	< 0.001
Transcervical hip fracture	0.2 days	-1.0 days (-1.1 to -0.9 days)	< 0.001
Charlson Comorbidity Index	-	+ 0.0 days (0.0 to 0.0 days)	< 0.001
Injury Severity Score	-	+ 0.2 days (0.2 to 0.2 days)	< 0.001
Hospital ACS level	-	+ 0.2 days (0.1 to 0.2 days)	< 0.001

See pages 47 - 108 for financial disclosure information.

Does Primary Wound Closure Following Open Fracture Affect Development of Deep Infection or Nonunion? A Prospective Cohort Study of 83 Subjects with 84 Open Fractures

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Purpose: The primary purpose was to determine the proportion of subjects developing deep infection or nonunion following primary closure of open fracture (humerus, radius/ulna, femur, tibia/fibula). Secondarily, a matched series analysis compared these outcomes with subjects who had undergone delayed closure after an open fracture in a previous cohort study. We hypothesized that primary closure would not adversely affect outcomes.

Methods: Between 2009 and 2013, 83 subjects with 84 open fractures who underwent primary wound closure at the initial surgery were enrolled prospectively at a Level I trauma center and followed for 1 year. Primary wound closure was performed when the Gustilo grade was 3A or lower and the wound was deemed clean at time of initial surgery. Demographics, injury information (eg, Gustilo grade, fracture site, injury mechanism, timing of antibiotic administration and initial surgery) were recorded. Subjects were evaluated postoperatively using standardized data forms until the fracture(s) healed. Phone interviews and chart reviews were undertaken at 1 year post fracture. These subjects were matched to a previous prospective cohort subjects with open fractures undertaken between 2001 and 2009 at the same center with similar selection criteria and study procedures. Subjects were matched on age, gender, fracture location, and Gustilo grade with blinding to outcomes at time of case matching. Nonunion was defined as unplanned surgical intervention after definitive wound closure or incomplete radiographic healing 1 year post fracture. Deep infection was defined as infection requiring unplanned surgical debridement and/or sustained antibiotic therapy following definitive wound closure. Descriptive analyses were undertaken on the primary closure cohort to examine outcomes. Matched analysis was undertaken on 68 pairs of subjects who were matched on all four variables(age, gender, fracture location, Gustilo grade). Unmatched subjects (n = 16 [19%]) were more likely to be older (P <0.001) females (P = 0.009) with lower-grade Gustilo(P = 0.009) upper extremity fractures (P = 0.009). There was no difference in union or infection outcomes between matched and unmatched subjects (P = 1.0).

Results: The majority (n = 52 [62%]) were male, the mean age was 47.2 ± 21.0 years, and almost half (n = 40 [49%]) had no coexisting conditions. Motor vehicle accidents were most common (n = 38 [49%]), followed by falls (n = 34 [42%]), crush injuries (n = 6 [7%]), and assaults (n = 6 [7%]). Fracture distribution was similar among upper extremity (n = 36 [43%]) and tibia/fibula (n = 44 [52%]) fractures while femur fractures were less common (n = 10 [12%]). Many (n = 46 [55%]) were isolated injuries. Follow-up (1-year interviews and/or clinical follow-up of >90 days) was completed by 82 (99%) subjects (83 fractures). Overall, 9 (11%) primary closure subjects developed nonunion while 3 (4%) subjects had deep infections. Two of the 3 subjects with deep infection also developed nonunion. In the matched analyses of 68 pairs (136 subjects), mechanism of injury and associated injuries were similar

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.

(P >0.36), but the delayed group reported more comorbidities (P = 0.009) and were more likely to receive external fixation (P = 0.001). The median time to operative management was similar between groups (P = 0.34), but median time to antibiotic administration was lower in delayed cohort (P = 0.009). Overall, there were more nonunions (n = 19 [29%]) and deep infections (n = 6 [9%]) reported in the delayed closure cohort than in the primary closure cohort (n = 8 [11%] nonunions; n = 3 [4%] deep infections) (P <0.001 for both; McNemar test for matched data).

Conclusion: In patients with lower/mid-Gustilo grade open fractures and wounds deemed clean at initial surgery, primary wound closure does not appear to increase the proportion of subjects who develop either deep infection or nonunion compared to delayed wound closure. Because this study was nonrandomized, further work is required to determine if primary wound closure reduces the development of nonunions and/or infections after open fracture.

See pages 47 - 108 for financial disclosure information.

BEST TRAUMA RELATED POSTER–2015 ORS MEETING

Correlation of NIRS and Histological Muscle Damage in a Prolonged Trauma/infusion Model of Extremity Compartment Syndrome (ECS)

Steven Budsberg, DVM

Background/Purpose: Extremity compartment syndrome (ECS) can result in devastating consequences if missed or if treatment is delayed. Recently, near-infrared spectroscopy (NIRS) has been shown to provide continual, real time, noninvasive measurement of regional perfusion in an infusion model of ECS. In a different model, NIRS evaluation of the compartment provided a reliable, sensitive measure correlating to both an increase and decrease in tibial intracompartmental pressures (TICP) and tibial compartment perfusion pressures (TIPP), respectively. Furthermore, significant correlations between muscle degeneration, edema, hemorrhage, and NIRS were found. The purpose of the study presented here was to evaluate the correlation between NIRS and histological muscle damage in a prolonged trauma / infusion model of ECS.

Methods: Six Landrace swine were used in the study. Pigs were maintained on isoflurane and positioned in dorsal recumbency. NIRS sensors (Nonin Medical) were placed on each leg with 1 cm of craniolateral compartment musculature proximal and cranial / caudal to the sensor. Two 18-gauge needles were centered under the sensor on both limbs and used for direct pressure transducer measurement of compartmental pressure as previously described. Continual time synchronized measurements of systemic blood pressure (systolic, diastolic, and mean arterial pressures, pulse rate, respiratory rate, compartmental pressures, and regional oximetry from the NIRS sensors) were collected. Baseline data were established for control and test craniolateral tibial regions. Trauma was induced by dropping a 2-kg weight 30 times from 100 cm directly on the test limb. NIRS sensors were replaced and albumin infusion elevated TICP to above mean arterial pressure yielding a TIPP below 0 mm Hg that was maintained for 8 hours. Pigs were randomly assigned to two groups. Three pigs were euthanized at 8 hours and cranial tibial muscle biopsies (scored for muscle damage) were taken. The other 3 pigs underwent fasciotomies and data were collected for an additional 2 hours at which time muscle biopsies were taken. A repeated-measures analysis of variance was used to test for differences in TICP, NIRS, and TIPP measurements between and within test and control limbs at each time point. Multiple comparisons were adjusted using Tukey test.

Results: As expected significant negative correlations of TICP and NIRS, and positive correlations of TIPP and NIRS were observed. NIRS values decreased relative to the control limb from compartment pressure-induced ischemia for the 8-hour duration and then rebounded to a hyperemic state following reduction of TICP.

Conclusion: The presence of delayed / missed ECS with muscle necrosis did not alter the characteristic NIRS response to ECS.

Does Resident Involvement Increase Complications in Orthopaedic Trauma?

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Purpose: In a new health-care landscape where quality metrics are becoming increasingly important, more focus has been placed upon the role of residents in patient care. Yet little data exist exploring the risk of complications when residents participate in the surgical care of the orthopaedic trauma patient. We explored the influence of residents on the rate of adverse events for orthopaedic trauma patients using the ACS-NSQIP (American College of Surgeons National Surgical Quality Improvement Program) database.

Methods: Using the ACS-NSQIP database, a prospective cohort of 22,099 orthopaedic patients from 2006-2013 were categorized by lower extremity, upper extremity, and hip/pelvis fractures using CPT codes. Demographics including age, sex, race, and comorbidities were recorded. The incidence of minor and major complications was also evaluated for patients. Bivariate analyses using the chi-squared test and Wilcoxon-Mann-Whitney test were performed to compare patient complications between the cases with and without resident involvement. Controlling for individual patient comorbidities, we used a multivariable regression model to determine the risk of developing a major, minor, or any complication with resident participation. Statistical significance was set at P <0.05.

Results: 22,099 patients were included in the analysis, of whom 7160 (32.4%) patients had residents involved in their surgical care and 14,939 (67.6%) had only an attending-level physician involved. As shown in Figures 1-3, no significant difference was found in the rate of major, minor, or all complications due to resident involvement for any anatomic region. After controlling for individual patient factors such as age, sex, and ASA (American Society of Anesthesiologists) status, resident involvement did not have a significant impact on the development of major, minor, or total complications. When further analyzing the incidence of complications by individual CPT codes, resident involvement was not significantly associated with increased adverse events.

Conclusion: Our data are the first to show that resident involvement does not negatively impact patient care in orthopaedic trauma. As quality measures become increasingly important, our study indicates resident involvement should not be a major concern.

Figure 1. Rate of Complications for LE (N=7,364, 33.3%)

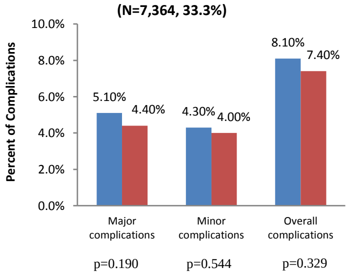


Figure 2. Rate of Complications for UE (N= 5,437, 24.6%)

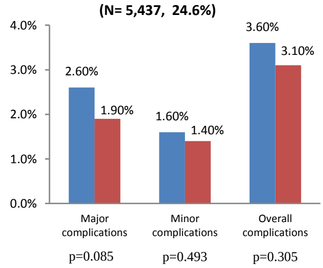
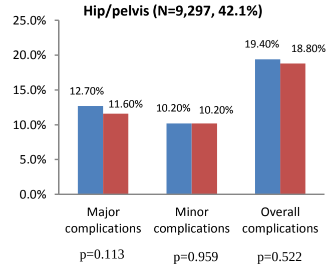


Figure 3. Rate of Complications for Hip/pelvis (N=9,297, 42.1%)



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Prospective Randomized Controlled Trial Using Telemedicine for Follow-up Visits in an Orthopaedic Trauma Population: A Pilot Study

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Background/Purpose: Proper follow-up is critical for patients sustaining orthopaedic trauma injuries. However, barriers to follow-up include inadequate finances, time away from work, large distances required to travel, and lack of transportation. Despite these challenges, many patients have home access to high-speed Internet. Therefore, the use of telemedicine (TM) video calls may be an alternative to in-person clinic visits as a solution to these barriers to follow-up. The purpose of this prospective, randomized controlled pilot trial is to investigate the feasibility of TM as a mechanism for follow-up in the orthopaedic trauma population.

Methods: After IRB approval, 24 total patients were recruited based on power analysis. Patients were recruited at the 2-week follow-up visit with inclusion criteria consisting of: age >18 years, closed fracture initially evaluated at the university, and access to TM video calls. Patients were randomly assigned into the control (C) (n = 12) or TM (n = 12) group. All patients had 2-week, 6-week, 3-month, and 6-month follow-up visits in this study. C patients had all visits in person at the university's clinic, while TM patients had 6-week and 6-month follow-ups occur through video calls. Prior to these two video calls, TM patients obtained radiographs of their fractures at local facilities that electronically submitted these radiographs to the university. Patients answered Likert-style surveys (1 = very unsatisfied, 2 = unsatisfied, etc) detailing their experiences at the conclusion of the study. Statistical analyses comparing patient satisfaction between the two groups were conducted with Mann-Whitney U tests.

Results: 12 patients were recruited into each arm of the study. 9 control patients (3 lost to follow-up) and 8 telemedicine patients (3 lost to follow-up, 1 sustaining an open fracture) completed the study. There were no significant differences between the C and TM group with satisfaction and complications (Table 1). Significantly fewer patients in the TM group (n = 0, 0%) took time off from work for appointments compared to the C group (n =5, 56%) (P = 0.03). In the TM group, patients traveled significantly fewer miles for a radiograph at a local facility (average 14.1 miles) compared to traveling to the university for in-person radiographs and visit (average 53.8 miles) (P <0.001). The TM group spent significantly less time per visit for video calls, including travel time for radiographs (79.4 minutes) when compared to in-person clinic visits (156.9 minutes) (P = 0.007, Fig. 1). Also no differences were seen in patient satisfaction.

Conclusion: This study was the first of its kind to illustrate telemedicine as an alternative to in-person clinic visits in the orthopaedic trauma population based on similar patient satisfaction, reduced time away from work, and reduced travel distance and time for visits with equivalent patient satisfaction in their medical care. TM may be used to decrease barriers to follow-up. Further study with a larger patient population is warranted.

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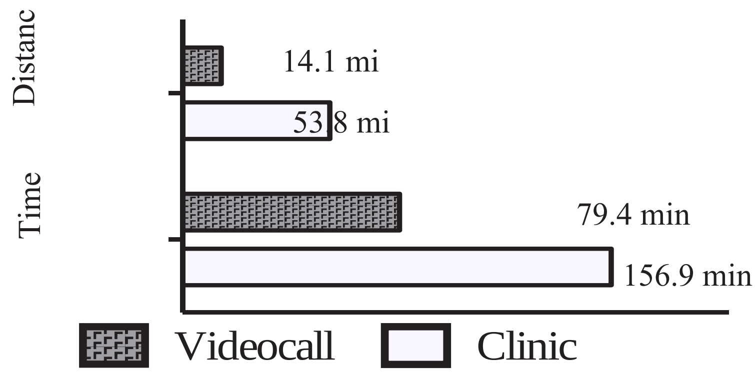
Table 1: C vs. TM groups

	C (n=9)	TM (n=8)	p
Overall satisfaction	4.56*	4.25*	0.74
Understood treatment	4.56*	4.50*	0.89
Took time off work	5/9 (56%)	0/9 (0%)	0.03
Complication rates	1/9 (11%)	1/8 (13%)	0.99

*Avg. response where 5 = very satisfied, 4 = satisfied, etc.

Figure 1: TM group analysis



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Identifying Clusters of Orthopaedic Trauma Patients at Risk for Poor Outcomes: Results from a Prospective, Multicenter Study

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Purpose: Numerous studies have demonstrated that long-term outcomes following orthopaedic trauma are related to psychosocial and behavioral health factors evident early in the patient's recovery. Less is known about how these factors relate to each other, and whether distinct clusters of individuals at varying risk of poor outcomes can be identified. The objectives of the study were to: (1) examine the distribution of known risk and protective factors in an orthopaedic trauma population, and (2) test whether these risk and protective factors could be used to classify individuals into risk profiles.

Methods: Participants (N = 681) with Abbreviated Injury Scale (AIS) 3 orthopaedic injuries were enrolled into a prospective, multicenter study. At 6 weeks post discharge, patients completed standardized measures for five risk factors: numeric rating pain intensity scale, depression (Patient Health Questionnaire [PHQ]-9), posttraumatic stress disorder (PTSD) (PTSD Check List), alcohol and tobacco use. Five protective factors were also measured: resilience (Connor-Davidson Resilience Scale), social support (Behavioral Risk Factor Surveillance System single-item scale), and 10-point self-efficacy scales for return to usual activity and managing the financial demands of recovery. Latent class analyses were used to classify participants into clusters. The sample was 64% male, 76% white, and had mean age 38.59 years and mean ISS score 16.6.

Results: A latent class analysis of the risk and protective factors supported a three-cluster solution (see table). Cluster 1 (n = 309) reflected low risk and high protection, cluster 2 (n = 256) reflected moderate risk and low protection, and cluster 3 (n = 116) reflected high risk and low protection.

Conclusion: The study shows trauma patients can be classified into meaningful risk/protective clusters. These clusters have important implications for the use and efficacy of psychosocial interventions and referral programs. The 45% of participants who fall into the low risk/high protection category are likely to achieve full recovery barring clinical complications and are unlikely to need additional services. The 38% of participants who fall into the subclinical risk/low protection category are at risk for pain, depression, and PTSD complications and have limited psychosocial resources, which could be improved with appropriate support services. The remaining 17% of participants fall into the severe risk/low protection category, and exceed widely used screening criteria for pain, depression, and PTSD. Aggressive referral and treatment will be critical for this subpopulation.

	Factors[1]	Overall	Cluster 1	Cluster 2	Cluster 3
Risk[2]	Pain	4.6 (2.7)	3.3 (2.2)	5.1 (2.4)	7.1 (2.1)
	Depression	7.7 (5.9)	3.8 (3.5)	8.4 (4.0)	16.3 (4.6)
	PTSD	16.7 (14.6)	7.6 (7.3)	16.8 (9.0)	41.3 (10.7)
	Alcohol Abuse, n (%)	80 (12)	25 (8)	42 (17)	13 (12)
	Tobacco Use, n (%)	198 (29)	41 (13)	97 (38)	60 (52)
Protective[3]	Resilience	6.5 (1.6)	7.1 (1.3)	6.2 (1.6)	5.5 (1.7)
	Social Support	2.1 (1.0)	3.6 (0.7)	2.9 (1.0)	2.5 (1.3)
	Return to Work	7.2 (2.9)	9.1 (1.3)	5.9 (2.8)	5.0 (2.9)
	Manage Finance	5.9 (3.3)	8.2 (2.1)	4.0 (2.7)	3.6 (3.0)

[1] Results expressed as mean (SD), except where otherwise indicated.
[2] Ranges (clinical cut-point): Pain: 0-10 (≥5); Depression: 0-30 (≥10); PTSD: 0-68 (≥30).
[3] Ranges: Resilience: 0-8; Social support: 0-4; Return to work: 1-10; Manage finance: 1-10.

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Physician Confidence in Managing Psychosocial Sequelae of Trauma: Impact of the Trauma Collaborative Care Initiative

Stephen Wegener, PhD; METRC TCCS Investigators

Background/Purpose: Despite improvements in the treatment of severe traumatic injury, survivors often experience physical and psychological challenges for years following injury. The Trauma Survivors Network (TSN) is a program designed to address these challenges. Guided by principles of secondary prevention and collaborative care, the program emphasizes partnership between the patient, physician, and a TSN coordinator (TSN-C), providing services early in the recovery process to prevent the development of common sequelae of trauma, including depression, chronic pain, and posttraumatic stress disorder. The impact of this program on physician confidence in managing the psychosocial sequelae of orthopaedic trauma was evaluated as part of a larger prospective, multisite, cluster clinical trial.

Methods: 12 Level I trauma centers participated in the trial: 6 control sites provided treatment as usual, and TSN services were implemented at 6 intervention sites, where a TSN-C provided targeted assessment and coaching activities for orthopaedic trauma patients. Trauma attendings and fellows were educated regarding the TSN services available and provided with patient risk assessments to guide care planning. A survey of all eligible orthopaedic trauma surgeons at the 12 centers was administered prior to the initiation of TSN activities (pre) and again at the end of participant recruitment (post). All orthopaedic trauma attendings and fellows were included at each time point, so respondents changed over time. The 10-item survey measured physicians' confidence in managing psychosocial complications. Survey items were measured on a 5-point Likert scale; responses ranged from "strongly disagree" to "strongly agree." For each item, an ordinal outcome regression model (with a random effect for site and adjustment for physician characteristics) was used to evaluate whether there was a differential effect between intervention and control sites with regard to improvement in physician confidence between the pre and post periods. The effect (beta) from these models is interpreted as the ratio of the odds ratio of higher level of confidence in the post versus pre periods for intervention versus control physicians (ratios greater than one favor the intervention group).

Results: 81 and 74 surgeons completed the pre and post surveys, respectively (91% response rate). At both time points, the age and gender breakdown between intervention and control physicians were comparable . However, physicians in the intervention sites tended to be more experienced in terms of number of years board-certified and years in current position than those in the control sites There was a statistically significant improvement between the pre and post assessment for intervention versus control physicians in their confidence to make referrals (beta = 5.02, 95% confidence interval [CI]: 1.49-16.98) and helpfulness of support personnel (beta = 4.85, 95% CI: 1.44-16.33). The effect estimates favored the TSN group for 7 of the 8 remaining confidence items (Table 1).

Conclusion: Based on surgeon self-report, the TSN provided in the context of a collaborative care model appears to benefit providers of care to orthopaedic trauma patients by increasing their perceived access to referrals and personnel to assist in managing psychosocial complications.

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.

Table 1: Summary of results

		Percent Agree or Strongly Agree				
		Control		Intervention		
	Survey Item\Period	Pre	Post	Pre	Post	Adjusted* Estimate (95% CI)
Confidence managing psychosocial complications	No time to ask about psychosocial issues	21	15	26	25	0.53 (0.16-1.79)
	Strategies to encourage pts to seek help	74	79	69	92	3.17 (0.83-12.03)
	Strategies to help pts change	43	47	45	67	2.22 (0.66-7.40)
	Confident can make referrals	**54**	**41**	**38**	**65**	**5.02 (1.49-16.98)**
	Ready access to information	32	24	22	44	2.40 (0.74-7.81)
	Ways to talk to pts to encourage action	56	59	43	70	2.85 (0.82-9.90)
	Ready access to personnel	37	35	29	52	2.68 (0.83-8.67)
	Support personnel can help	**55**	**61**	**36**	**60**	**4.85 (1.44-16.33)**
	Ready access to mental health svcs	53	34	35	48	3.08 (0.92-10.28)
	Mental health svcs to can meet pt needs	46	33	34	41	2.78 (0.82-9.38)

* Ratio of the odds ratio of higher level of agreement (with the survey item) in the post vs. pre periods for intervention vs. control physicians (ratios greater than one favor the intervention group).

Δ Culture-Independent Measures of the Traumatic Open Fracture Microbiome to Predict Clinical Outcomes

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Background/Purpose: Predicting which patients with open fractures will have an infection and/or infection-related complication, such as nonunion/malunion or amputation, remains problematic. Surveillance cultures generally have little predictive value, probably because the majority of microbes are not cultivable under standard laboratory conditions. We previously reported pilot results of the open fracture microbiome using culture-independent, high-throughput DNA sequencing of bacterial 16S ribosomal RNA (rRNA) genes, and analyzed those communities with respect to injury mechanism, severity, anatomic site, and infectious complications although the small number of subjects and short-term follow-up at the time of our initial work constrained our understanding. The objective of this current study is to systematically evaluate whether the traumatic open fracture microbiome is a source of clinically relevant markers that are predictive of outcomes.

Methods: 52 subjects with open fractures were enrolled into a prospective longitudinal study. Microbiota were collected using wound swabs at presentation to the emergency department, intraoperatively, at every outpatient follow-up, and in the event that additional surgical intervention was required. 16S rRNA gene sequencing was performed to assess bacterial load, bacterial diversity, and presence and relative abundance of potential pathogens. Outcomes were defined by whether or not surgical intervention was required during the initial 6 months of follow-up. Samples were clustered into microbial community types as defined by Dirichlet mixture modeling. Logistic regression models were used to determine the predictive value of Dirichlet community types, bacterial diversity, bacterial load, and the relative abundance of potential pathogens including Staphylococcus, Streptococcus, Acinetobacter, Pseudomonas, Klebsiella, and Enterobacter. Models were adjusted for covariates: mechanism of injury, fracture severity, and fracture location.

Results: Of the 52 enrolled subjects, median age was 40 ± 17 years; 65% were black, 30% were white; and 76.9% were male. Lower extremity fractures were dominant in our population (n = 45, 86%) and no participants had both upper and lower extremity injuries. Outcomes to date include 20 subjects who healed, 12 confirmed nonunions, and the remaining 20 lost to follow-up or still in follow-up with final disposition pending. As illustrated by the example in Figure 1, the open fracture microbiome is dynamic and distinct perturbations were apparent when surgical intervention was required (indicated by arrows). Our preliminary analyses indicate that microbial diversity and composition are associated with infection-related outcomes, and longitudinal assessment of the microbial communities provides greater power for detection.

Conclusion: The open fracture microbiome is dynamic and more complex than standard clinical cultures or clinical presentation can capture. Application of high-throughput genomic

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identification and bioinformatics analysis of microorganisms present in open fractures suggest that the microbiome may be used as a prognostic biomarker for clinically meaningful outcomes.

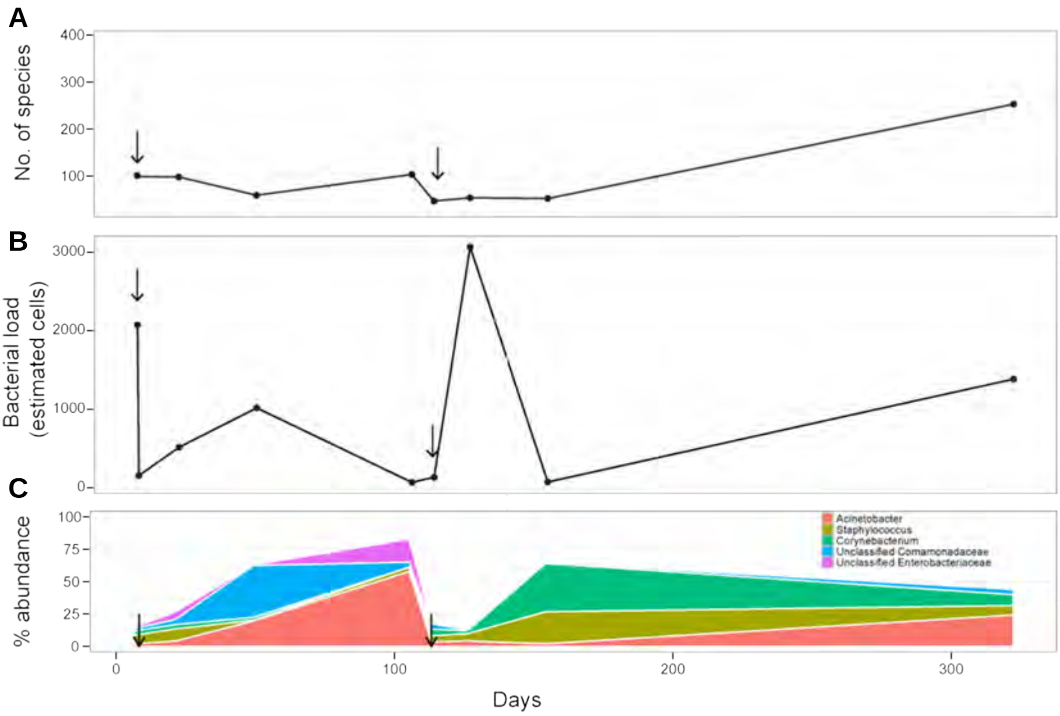

Figure 1
Example of dynamic microbiome of patient presenting with tibial fracture and developing nonunion in approximately 100 days. A, Bacterial diversity, as measured by the number of species observed (Y-axis) in the open fracture. Diversity decreases with nonunion and increases as healing proceeds. B, Bacterial load (Y-axis) is variable throughout the healing course and offers little predictive value. C, Relative abundance of the top 5 most abundant bacteria (Y-axis). Acinetobacter increases leading up to the nonunion and is replaced by other species following repair.

POSTER ABSTRACTS

See pages 47 - 108 for financial disclosure information.

Rate and Risk Factors for Delayed Healing Following Surgical Treatment of Lateral Condyle Humerus Fractures in Children

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Purpose: The purpose of this study was to evaluate the rate and risk factors for delayed healing of pediatric lateral condyle fractures after surgical fixation.

Methods: In this retrospective study of all operatively treated lateral condyle fractures at a single institution from 2006 to 2013, radiographic evaluation included: measured fracture displacement at presentation and after surgical fixation, fracture classification, and multiple parameters of pin configuration. Patients who had delayed healing were defined as those not yet healed by the 8th week of follow-up. The delayed healing group was compared to fractures that healed in less than 8 weeks to identify risk factors associated with delayed healing. Purposeful selection was utilized to identify factors for entry into a multivariate binary logistic regression model.

Results: 210 children were evaluated. Mean follow-up was 25 weeks (range, 4 weeks-5 years). Distribution of Weiss et al classification was as follows: type 1, 8 (4%); type 2, 61 (29%); and type 3, 141 (67%). There were 33 (16%) delayed unions, of which 7 (21%, 3% of the entire cohort) required further surgery to achieve healing. There was no significant difference in pin configuration and treating surgeon experience between the delayed healing group and the normal healing group (P = 0.64), however all 7 cases that underwent secondary surgery were initially treated by surgeons in their first 2 years of practice. Weiss classification, intraoperative fluoroscopy time, and intraoperative displacement after fixation met criteria for entry into the regression. While Weiss classification did not remain significant within the model, its removal resulted in a 30% change in the parameter estimate for intraoperative fluoroscopy time. For each second increase in fluoroscopy time, there was a 3% increase in the risk of delayed healing. For every 0.1-mm increase in intraoperative displacement after fixation, there was an 18% increase in the risk of delayed healing. Patients with 1 mm or more displacement after fixation had an increased risk of delayed healing (odds ratio [OR] 4.78, P = 0.007).

Conclusion: Delayed union of lateral condyle fractures is a matter of concern and in this series 3% required secondary surgery to achieve healing. Risks for delayed healing include amount of residual displacement after reduction and the difficulty in attaining that reduction, as defined by fluoroscopy time. Families with children who have severe fracture patterns, particularly in cases where anatomic reduction could not be obtained, should be counseled of the elevated risk of complications related to healing.

Closed Reduction and Percutaneous Pinning Versus Open Reduction and Internal Fixation of Mildly Displaced Humeral Lateral Condyle Fractures

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Purpose: The optimal treatment for pediatric lateral condyle fractures that are mildly displaced is unclear. The purpose of this study was to assess clinical and radiographic outcomes and complication rates of patients undergoing open reduction and internal fixation (ORIF) versus closed reduction and percutaneous pin fixation (CRPP) of mildly displaced lateral condyle fractures.

Methods: A retrospective review of all children with acute lateral condyle fractures with 2-5 mm of displacement measured at the lateral cortex and no significant rotational displacement or joint surface incongruity treated at a single Level I trauma center from 2006 to 2014 was performed. A total of 74 patients were treated who met inclusion criteria; 51 underwent ORIF and 23 underwent CRPP. No differences existed between the two groups with respect to age, gender, extremity, mechanism of injury, time to treatment, fracture displacement, or fracture classification. Charts and radiographs were reviewed and the following parameters were documented: operating room (OR) time, time to union, return to activities, magnitude of lateral spurring, and complications. Major complications were defined as those with presumptive long-term effects or requiring reoperation.

Results: The average follow-up for the entire cohort was 6 months. All fractures healed within 12 weeks of surgery, regardless of treatment type, and no differences were observed in time to union between the groups. OR time averaged 30 minutes faster for the CRPP group ($P < 0.001$). Nearly 10% of patients in each group developed elbow stiffness, requiring formal therapy. The overall complication rates were 25% for the ORIF group and 13% for the CRPP group ($P = 0.36$). No major complications were observed in the CRPP group, whereas 3 (6%) were observed in the ORIF group, including one case of osteonecrosis with a fishtail deformity, one case of osteomyelitis requiring two surgical debridements complicated by a premature physeal closure and angular deformity, and one refracture requiring surgery.

Conclusion: Surgical treatment of lateral condyle fractures mildly displaced 2-5 mm has good outcomes regardless of treatment. CRPP, however, minimizes surgical time, is more cosmetic, and potentially reduces complications. Further studies with additional patients, better assessment of articular surface displacement, and longer follow-up will be necessary to corroborate these findings. However, our results provide guidance to physicians treating mildly displaced lateral condyle fractures requiring surgery.

See pages 47 - 108 for financial disclosure information.

Cervical Spine Trauma Immobilization Protocols in Young Children: How Often Are These Protocols Followed?

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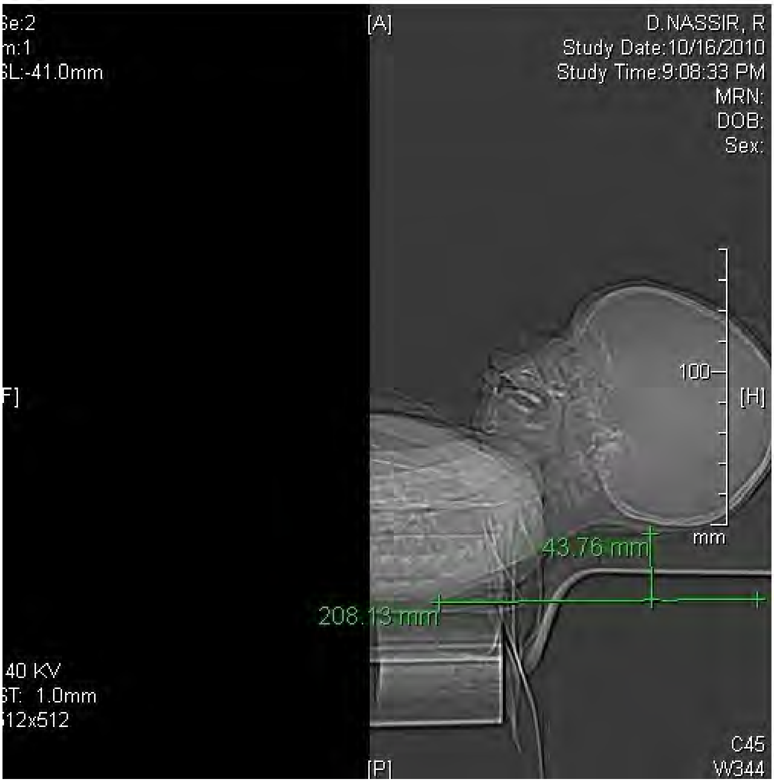
Background/Purpose: Due to the fact that children have a larger head:torso size ratio, positioning them on a standard flat backboard during CT examination will place the cervical spine in a flexed position. This flexed position can lead to exacerbation of a cervical spine injury, especially in unconscious patients in which a neurologic examination cannot be obtained. Backboards with occipital recesses or split mattresses have been developed to alleviate these problems. The purpose of this study is to determine the rate of appropriate positioning of children undergoing cervical spine CT in a high-volume pediatric Level I trauma center.

Methods: After IRB approval, the trauma registry was reviewed for all patients age 7 or younger who had a CT scan of the cervical spine as part of a trauma evaluation from 2009-2014. During that time, patient positioning was determined by either emergency medical personnel in the field or the emergency department (ED) team upon arrival to the ED using a pediatric-specific protocol. All consecutive patients with appropriate radiographs were included. Head positioning was determined by measuring the vertical displacement of the occipital protuberance above the plane of the posterior aspect of the thorax on the CT scout view. Patients with the occipital protuberance posterior to the posterior aspect of the thorax were considered to be positioned correctly. The amount of occipital displacement relative to the thorax was recorded.

Results: A total of 158 CT scans were obtained, of which 135 (85%) were adequate for review. Of these, 66 (49%) had the occipital protuberance elevated above the level of the posterior thorax, indicating a relative hyperflexion of the cervical spine. The mean anterior displacement of the occipital protuberance was 2.0 cm (range, 0.5-3.4 cm). Of these patients, none had a positioning device used. Of the 69 patients with the occipital protuberance posterior to the thorax, the mean displacement was 1.1 cm posterior (range, 0.2-4.2) to the thorax and all had a positioning device used.

Conclusion: Despite having a cervical immobilization protocol and positioning devices, 49% of children presenting to a pediatric Level I trauma center were not positioned correctly for CT imaging. Constant review and education of health-care providers is needed to ensure that cervical spine immobilization protocols are followed in order to prevent unwanted cervical flexion in the young child with suspected cervical spine trauma.



See pages 47 - 108 for financial disclosure information.

Pelvic Ring Injuries in the National Trauma Data Bank: Miscoded, Misclassified, or Misunderstood?

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Purpose: The American College of Surgeons has advocated participation in the National Trauma Data Bank (NTDB) for all trauma centers; however, no prior study has evaluated the accuracy of coding included in this data bank. The purpose of this study was to determine whether pelvic ring injuries are coded accurately in the NTDB, and, if not, how they were misclassified.

Methods: A retrospective review of all pelvic ring injuries based on Abbreviated Injury Scale (AIS) codes was performed at a single Level I academic trauma center from July 2010 to June 2013. A single fellowship-trained orthopaedic trauma surgeon reviewed thin-section CT scans in all patients and classified the injuries using AIS: posterior arch intact, incomplete posterior arch, or complete posterior arch. The surgeon was blinded to the AIS code and trauma code level from the registry. These CT-based classifications were compared with the pelvic ring injury codes designated trauma registry for each patient.

Results: 235 patients with a mean age of 42 years had pelvic ring injuries in our registry. The agreement between trauma registry codes and CT reclassification was 24% in the intact group, 43% in the incomplete group, and 59% in the complete group. Using only the trauma registry codes, injuries were underclassified in 48% of the incomplete group and 76% of the intact group.

Conclusion: Many pelvic ring injuries are miscoded and misclassified in the NTDB. The etiology of this misclassification is unclear, but any research data mined from these data bases should be regarded cautiously.

APC Injuries with Symphyseal Fixation: What Affects Outcome?

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Background/Purpose: Symphyseal separation is routinely treated operatively. Normal motion through the region leads to loosening of fixation and plate failure in up to 40% of cases, some of which allow for union with some separation. Additionally, the posterior ring may be rotationally or completely unstable. There is little known about the functional outcomes of patients with this injury after 2 years. The purpose of this study was to evaluate the influence of the position at union, hardware failure or loosening, ISS, and the type of posterior ring injury (type 2 or 3) on validated outcomes in a series of patients treated operatively for symphyseal separation.

Methods: We evaluated 54 patients (50 male, 4 female), average age 54 years (range, 23-80), ISS mean 17 (range, 8-50), with 35 APC (anterior-posterior compression) 2 and 19 APC3 injuries at minimum of 2 years after surgery (average 7 years; range, 2-14). All patients were stabilized with a 6-hole anterior plate. Type 2 injuries were not fixed posteriorly and type 3 injuries were treated with iliosacral screws in addition to the symphyseal plate. Patients were evaluated with EuroQol EQ5D, EQ health index, visual analog scale (VAS) pain, and Majeed pelvic scores. Hardware failure was defined as loosening or breakage of screws and/or plate. Separation of the symphysis at follow-up was measured as the maximal separation on the AP view looking at the superior one-half of the symphyseal bodies. Three patients had revision surgery and they are included based on hardware status and displacement at the time of final followup. Statistical analysis was performed using Fisher exact, t tests, and Pearson's correlation coefficient as appropriate.

Results: We found trends toward better outcomes for APC2 versus APC3 injuries for EQ5D and VAS pain only. There was no difference in Majeed score or reported health status. 15 patients had failure of fixation on their final films; this was not associated with a difference in EQ5D, VAS pain, or reported health and there was a trend towards a better Majeed score. Multiply injured patients (ISS >16) had worse reported health, Majeed, and VAS pain. All of these data is summarized in the table. There was no correlation of final symphyseal separation on EQ5D (Pearson correlation coefficient R = -0.1). In looking at major displacement defined as >15 mm, there was a difference or trend in EQ5D (P = 0.03), reported health (P <0.0001), and Majeed score (P = 0.06), but not in VAS (P = 0.4). No factor affected the need to change jobs for those who were employed. Final outcomes for the 3 patients who were revised were not different than those not revised (P values 0.26 -1 for all outcomes).

Conclusion: We followed 54 patients with APC2 or APC3 pelvic injuries for a minimum of 2 years (average 7 years) to evaluate the factors that influence outcomes. There was no difference seen in APC2 versus APC3 injuries, but overall injury severity resulted in lower scores and more pain. Outcomes were not affected by hardware loosening or breakage. There was no correlation of EQ5D with final displacements when evaluated continuously;

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however, displacements of >15 mm anteriorly did negatively impact outcomes. Minor loss of reduction <15 mm anteriorly does not seem to affect patient-based outcome, pain level, or work status. Finally, patients who had early failure and were revised to union in a good position did not suffer worse outcomes than those who healed uneventfully.

	EQ5D	**EQ Health**	**Majeed**	**VAS Pain**	**Work Δ**
APC2	82 ± 19	76 ± 19	77.4 ± 14	1.3 ± 1.8	39%
APC3	74 ± 21	72 ± 22	81.5 ± 20	2.4 ± 2.4	50%
P Value	**0.15**	**0.4**	**0.39**	**0.06**	**0.77**
ISS ≤ 16	81 ± 21	78 ± 18	79 ± 14	1.1 ± 1.6	36%
ISS > 16	71 ± 23	68 ± 22	70 ± 20	2.8 ± 2.6	57%
P Value	**0.38**	**0.08**	**0.06**	**0.005**	**0.23**
Hardware Intact	80 ±21	76 ±20	81.5 ± 16	1.9 ± 2.3	33%
Hardware Failed	80 ±18	70 ± 19	71.9 ± 18	1.6 ± 2.1	47%
P Value	**.71**	**0.3**	**0.06**	**0.66**	**0.5**

The Incidence of and Factors Affecting Iliosacral Screw Loosening in Pelvic Ring Injury

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Background/Purpose: Iliosacral screw fixation has been commonly used for stabilization of the posterior ring in unstable pelvic fractures. However, loosening of the screw may develop with or without redisplacement of the fracture, and there is a paucity of published information regarding the incidence of and factors affecting iliosacral screw loosening. This study was undertaken to evaluate the incidence of iliosacral screw loosening and to identify predictive factors.

Methods: 110 patients whose posterior pelvic ring was stabilized with iliosacral screws from September 2001 through December 2012 were enrolled in this study. There were 61 men and 49 women, with a mean age of 45.2 years. The mechanism of injury was traffic accident for 55 patients, a fall from a height for 38 patients, and a work-related crushing injury for 17 patients. According to the Young–Burgess classification, there were 9 cases of anteroposterior compression, 64 cases of lateral compression, and 37 cases of vertical shear (VS) injuries. Among those with posterior pelvic ring injuries, 95 had sacral fractures (zone I, n = 52; zone II, n = 43, Denis classification) and 15 had sacroiliac joint dislocations. For 82 patients, both anterior and posterior rings were stabilized, whereas the remaining 28 patients underwent only posterior ring fixation with iliosacral screws. Screws were fixed to the anterior one-third region of the first sacral (S1) body in 46 cases, and to the middle one-third region of the S1 body in the remaining 64 cases. If loosening of the iliosacral screw influenced the pelvic ring stability and revision surgery was required, it was considered a failure. The relationship between iliosacral screw loosening and age, fracture pattern, operative method, location of the screw within the S1 body, and the type of the sacral fracture were analyzed using Pearson chi-square test with significance set at $P < 0.05$.

Results: All fractures healed at an average period of 15 weeks after surgery (range, 12-20 weeks). 19 of 110 patients (17.3%) were found to have loosening of the iliosacral screw at an average of 25.3 days (range, 10-70 days) after the index operation. The incidence of iliosacral screw loosening was significantly higher in those with VS injury (29.7%, $P = 0.014$), in those with the screw fixed to the middle one-third region of the S1 body (23.4%, $P = 0.044$), and in those with VS injury combined with zone II sacral fracture (43.5%, $P = 0.019$). Patients with VS injury also had a higher incidence of failure. (21.6%, $P = 0.036$).

Conclusion: Although iliosacral screw fixation is a reasonable method for posterior pelvic ring stabilization, caution should be taken to prevent screw loosening in VS injury. Screw fixation to the anterior one-third of the S1 body can decrease the incidence of loosening. Furthermore, alternative methods of fixation should be considered in VS injury, especially when combined with zone II sacral fracture.

See pages 47 - 108 for financial disclosure information.

Reduction of Symphyseal Diastasis During CT Scan

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Purpose: We sought to determine the quantifiable difference in pubic symphysis diastasis when comparing CT scan and pelvic radiographs in individuals with anterior pelvic ring injuries.

Methods: This was a retrospective chart and radiographic review in a Level I trauma center. Between 2002 and 2013 all individuals requiring internal fixation of anterior pelvic ring were reviewed. Out of 163 patients, 72 met inclusion criteria. Patients with symphysis diastasis were included if the pelvic radiograph and CT scan were performed without a pelvic binder and imaging was adequate for required measurements. Symphyseal diastasis was measured on the initial pelvic radiograph, and the CT scout and axial views. The main outcome measurement was a comparison of measured symphyseal diastasis on CT scan and pelvic radiographs.

Results: 72 patients met inclusion criteria. 97% (70 of 72) had a reduction of their symphysis diastasis in the CT with an average reduction of 6.6 mm (range, -2.6 to 35.5 mm). The average diastasis on radiograph was 26.3 mm compared to 19.7 mm on CT scout (P <0.001). 14 patients (19.2%) had a reduction from greater than 25 mm to less than 25 mm, a traditional cut-off for operative intervention.

Figures: AP pelvis X-ray, Scout CT, Axial CT prior to application of pelvic sheet

Conclusion: The AP pelvis radiograph remains an important part of the workup for trauma patients. Reliance on CT scan alone underestimates true degree of pelvic displacement. Not obtaining pelvic radiographs in the acute setting limits the information on which the medical team can base both short-term and long-term decisions in regards to pelvic ring injuries.

Does Pelvic Embolization Increase Infection Rates in Patients Who Undergo Open Treatment of Acetabular Fractures?

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Purpose: There is a paucity of literature on the effect of pelvic embolization on postoperative infection rates following open reduction and internal fixation (ORIF) of acetabular fractures. Existing literature would suggest rates are unacceptably high. We sought to evaluate our institution's infection rates after ORIF of acetabular fractures and pelvic embolization.

Methods: This is an IRB-approved retrospective review of prospectively gathered data at a regional Level I trauma center to identify patients who underwent ORIF of acetabular fractures and pelvic angiography from 2005 through 2012. We compared three groups to examine the rates of superficial and deep tissue infection rates between three cohorts: (1) control (controlled for intensive care unit stay and ISS), 35 acetabular patients who did not undergo angiography; (2) angiography (no embolization), 17 acetabular fracture patients who underwent angiography with no identifiable bleeding source; and (3) angiography (embolization), 24 acetabular fracture patients who underwent angiography with an identifiable bleeding source that was selectively embolized.

Results: 74 angiography patients and 35 control patients were identified. 33 angiography patients were excluded: 19 lost to follow-up, 7 for death within the acute hospital stay, and 7 for angiography on the limb contralateral to the acetabular fracture. 41 patients remained for final analysis: 24 patients who underwent embolization and 17 patients who underwent angiography with no embolization. Embolization was performed as follows: 17/24 patients with gel foam, 2/24 with coils, and 5/24 with coils and gel foam. One (4%) deep infection and one (4%) superficial infection occurred in the embolization group. There were 5 (29%) deep infections in the nonembolization group. There was 1 (3%) deep infection in the control group. There was a significantly higher number of deep infections in the nonembolized angiography group.

Conclusion: Despite previous reports of high infection rates after pelvic embolization, we noted a deep infection rate of 4% after embolization and an infection rate of 29% in patients who underwent angiography without embolization. This suggests that pelvic embolization does not lead to higher rates of infection and can be performed safely when indicated. The high rate of infection in the nonembolized group suggests that there may be a component of vasospasm or hypoperfusion secondary to low blood pressure during the initial angiography that led to a missed bleeder that resulted in a hematoma, which was subsequently infected. Further investigation is warranted.

See pages 47 - 108 for financial disclosure information.

The Risk Factors of Neurologic Deficit After Fixation of Zone 2 Sacral Fractures

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Purpose: Zone 2 sacral fractures account for 34% of sacral fractures with reported neurologic deficit in 28% of the patients. The purpose of this study was to examine the risk factors for neurologic injury in zone 2 sacral fractures.

Methods: A retrospective review of consecutive patients admitted to a Level I trauma center with zone 2 sacral fractures requiring surgery from September 2010 to September 2014 was performed. Patients were excluded if no neurologic exam was available after surgery. Fractures were classified according to Denis and presence / absence of comminution through the neural foramen was noted. Fixation schema was recorded (sacral screws, anterior open reduction and internal fixation, or posterior tension plate). Any change in postoperative neurologic examination was documented as well as examination at last clinic encounter.

Results: 92 patients met inclusion criteria, with zone 2 fractures and neurologic exam. 85 patients (92.3%) were intact neurologically in their last follow-up examination. Of the 7 patients with postoperative neurologic deficit, 3 had a neurologic deficit prior to surgery and 4 had no documented neurologic examination prior to surgery. Of the entire cohort, at final follow-up, only one patient had nonunion that required revision. Focusing on fracture pattern, 56 fractures (60.8%) were simple fractures and 36 fractures (39.2%) were comminuted fractures. All 7 patients with neurologic deficit had comminuted fractures. The association between neurologic deficit in zone 2 sacral fracture and fracture comminution was found to be statistically significant ($P = 0.002$).

Conclusion: The use of partially threaded screws for zone 2 sacral fractures does not cause neurologic injury, suggesting that compression through the fracture does not cause iatrogenic nerve damage. The low rate of sacral nonunion can be attributed to compression induced by the partially threaded compression screws. Zone 2 fracture comminution is a risk factor for neurologic damage.

Bilateral Sacral Fractures are Highly Associated with Lumbopelvic Instability

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Purpose: Bilateral sacral fractures with associated lumbopelvic instability can lead to neurologic injury and morbidity not seen in other sacral fracture patterns. Although the diagnosis can be missed on plain radiographs as well as cross-sectional imaging, the presence of bilateral sacral fractures seen on axial CT or MRI is thought to be highly suggestive. This study was designed to formally evaluate the effectiveness of using bilateral sacral ala fractures to diagnose lumbopelvic instability.

Methods: A retrospective analysis of all sacral fractures treated at a Level I trauma center from 2000-2014 was undertaken. Unilateral and bilateral sacral ala fractures evaluated with CT or MRI imaging including sagittal reconstructions were included. The presence of an associated transverse fracture with or without sagittal plane deformity was used to define lumbopelvic instability and the Roy-Camille classification system was applied. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated.

Results: Of 1526 diagnosed sacral fractures, 490 with eligible imaging were identified. This included 443 unilateral sacral ala fractures and 47 bilateral sacral ala fractures. 41 (87%) of the bilateral fractures had a transverse component indicating some degree of lumbopelvic instability. 27 (66%) were Roy-Camille Type 1, 11 (27%) were Type 2, and 3 (7%) were Type 3. A review of 443 unilateral fractures demonstrated no lumbopelvic instability. Presence of bilateral sacral ala fractures had 100% sensitivity and 100% NPV for detecting lumbopelvic instability (Table 1).

Conclusion: Bilateral sacral fractures seen on axial cross-sectional imaging are highly suggestive of some degree of lumbopelvic instability and should alert the treating physician to closely scrutinize the sagittal reconstructions.

	+ Lumbopelvic Instablity	**- Lumbopelvic Instablity**	
+ Bilateral Sacral Ala Fractures	39	7	***Positive Predictive Value: 85%*** *(39/39+7)*
- Bilateral Sacral Ala Fractures	0	46	***Negative Predictive Value: 100%*** *(46/46+0)*
	Sensitivity: 100% *(39/39+0)*	***Specificity: 87%*** *(46/46+7)*	

See pages 47 - 108 for financial disclosure information.

Risk Factors for Conversion to Total Hip Arthroplasty After Posterior Wall Acetabular Fracture

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Purpose: There is a growing interest in performing acute total hip arthroplasty (THA) for acetabular fractures in cases in which open reduction and internal fixation (ORIF) is suspected to fail. The purpose of this study was to identify risk factors for early conversion to THA in an effort to aid in counseling patients and selecting the optimal treatment.

Methods: The institutional trauma database was searched for patients with acetabular fractures involving the posterior wall from 2005 to 2010 managed with ORIF. Preoperative CT scans, intraoperative imaging, postoperative CT scans, and the operative reports of patients were reviewed. Participants were contacted by telephone to document reoperations and functional outcomes including the Short Form (SF)-8 and modified Merle d'Aubigne Hip Scale.

Results: There were 65 patients with both pre- and postoperative CT scans who were contacted at a mean of 6.9 years (range, 4-9.3) after surgery. There were 29 (44.6%) isolated posterior wall, 25 (38.5%) transverse posterior wall, 6 (9.2%) posterior-column posterior wall, and 5 (7.7%) T-type with an associated posterior wall fracture. The overall rate of conversion to THA was 16.9% (11/65). Presence of dislocation, comminution of the posterior wall, femoral head impaction, acetabular impaction, and intra-articular loose bodies all trended toward an association with conversion to THA. Presence of all five radiographic features was associated with a 50% (5/10) rate of conversion to THA in contrast to 10.9% (6/55) if four or less features were present (P = 0.009). Age, gender, time to closed reduction, and presence of an associated acetabular fracture were not significantly associated with conversion to THA. Among cases with less than 1 mm of diastasis and step-off on postoperative CT scan there were no THA conversions (0/8) compared to 9.1% (4/40) for 1 to 4 mm and 53.9% (7/13) if either step-off or diastasis was 4 mm or more (P = 0.001). The presence of all five radiographic features of severe injury was associated with a reduction step-off or diastasis greater than 4 mm in 60% of cases (6/10) compared to 12.7% (7/55) of less severe injuries (P = 0.005). There was no difference in SF-8 (16.4 vs 17.4, P = 0.63) or modified Merle d'Aubigne scores (8.0 vs 8.9, P = 0.39) comparing patients who underwent THA and those who did not.

Conclusion: Posterior wall acetabular fractures associated with the combination of dislocation, comminution, intra-articular loose bodies, femoral head impaction, and acetabular impaction are associated with more difficult reduction and higher rate of conversion to THA in comparison to less severe injuries. Patients should be counseled accordingly about the need for future arthroplasty and consideration can be given to primary THA in these severe cases. When ORIF is undertaken, anatomic restoration of the acetabulum to within 1 mm of both step-off and diastasis, which cannot be accurately detected with plain radiographs, is associated with the lowest risk of posttraumatic arthritis.

Clinical and Radiological Outcomes of the Anterior Subcutaneous Internal Pelvic Fixator

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Background/Purpose: The use of an anterior external fixator (Exfix) in the treatment of pelvic injuries is effective and may be lifesaving. Exfix is associated with pin tract infections (25%-50% of patients), osteomyelitis (7%), loosening (10%), loss of reduction (up to 33%), is difficult to use in obese patients, and can be restrictive to movement. The anterior subcutaneous internal pelvic fixator (Infix) device attempts to address these issues but has its own complications, which include heterotopic ossification (HO), lateral femoral cutaneous nerve irritation, loss of fixation, and recent reports of femoral nerve palsy. The purpose of this study is to evaluate our clinical and radiological outcomes with the Infix device over the last 6 years.

Methods: An IRB-approved retrospective study was performed. 73 patients who suffered an unstable fracture of the pelvic ring and were subsequently treated using Infix were included. 67 suffered a traumatic fracture, while 6 were pathologic fractures. 11 patients were placed in an Exfix before being converted to Infix. The patient population included 4 A, 37 B, and 36 C AO/OTA type injuries. The average ISS was 23.21 ± 11.26 (range, 5-57) , follow-up was 31.27 months (range, 12-80.37). Six patients died prior to 12-month follow-up unrelated to the device. BMI (body mass index) was 27.1 ± 7 (with 30% over 30 and 18% over 35). Reduction and loss of reduction was measured using the "Keyshiyan cross method," injuries to the pubic symphysis were measured directly and healing was assesed by radiographs at each follow-up. Functional outcome was assessed using the Majeed pelvic scoring system. HO was judged as none, mild (diffuse or <15 mm), moderate (dense and >15 mm), and severe (dense and >30 mm).

Results: The average reduction of the pelvic injuries as measured using the Keshiyan method was 40.77%. The average reduction in pubic symphysis injuries was found to be 63.48%. Reduction was maintained after removal and all patients healed. HO was a common occurrence. We found absence of HO in 32% of patients (ISS 18.78), some HO in 32% (ISS 21.2), and severe 36% (ISS 25.62) . HO severity was positively correlated with the ISS (P <0.05). HO was symptomatic in 2 patients, one we felt was directly related to the Infix and needed excision and the other not related to the Infix that led to an ankylosed hip that also needed excision. Other complications were persitant paresthesias in the distribution of the lateral femoral cutaneous nerve (8 cases, none problematic at latest follow-up), problems with implantation of the device (3 cases in the first series), pain associated with the device (3 cases) leading to early removal, and surgical site infection (4 cases), but no instance of femoral nerve palsy. The Majeed outcome score (average 78.87 ± 13.91; range, 47-100) rated the patients as excellent, 35%; good, 38%; fair, 23%; poor, 4% and was correlated with length of follow-up (>24 monoths 83.39 vs <24 months 72.67, P <0.05) and ISS.

See pages 47 - 108 for financial disclosure information.

Conclusion: Infix has benefits over an external fixator that make it more desirable for use in pelvic ring injuries but is not complication free. Most of the technical difficulties were noted in the original 30 cases performed. Good reduction was achieved and maintained until healing. Many patients had multiple injuries that affect outcome measures. Patients continue to improve over time and much improvement continues to take place after 24 months postoperatively.

The Value of "Binder-Off" Imaging for Identifying Occult and Unexpected Pelvic Ring Injuries

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Background/Purpose: Pelvic fractures occur in 5% to 16% of patients with blunt trauma and can cause life-threatening hemorrhage. Pelvic binders are becoming a routine part of the initial management of trauma patients with suspected pelvic fractures, being placed by paramedics on the scene. Anecdotal reports have suggested serious pelvic injuries may be missed or not fully appreciated in the presence of a pelvic binder that has been applied and has anatomically reduced the pelvic ring. For this reason our departments now perform additional pelvic imaging following removal of the pelvic binder where there is still suspicion of a pelvic injury, unless hemodynamic instability precludes it.

Methods: A retrospective review of all patients presenting to our tertiary referral unit over a 2-year period with significant pelvic ring injuries was conducted. Images (CT and radiographs) of the pelvis with the binder on and off were assessed to identify the frequency at which further imaging changed patient management.

Results: 97 patients were identified from our prospective database. 71 patients had initial imaging with a pelvic binder in situ and 54 of these patients had "binder-off" radiographs. We identified 2 patients with occult anteroposterior compression injuries not seen on imaging in binder, and 2 in whom images in binder were classified as lateral compression type I injuries, but binder-off images revealed unexpected symphysis diastases.

Conclusion: Trauma imaging of pelvic injuries performed with a pelvic binder in situ is inadequate at fully assessing the pelvic ring. In 7% of significant pelvic trauma cases the pelvic ring injury is masked or underestimated with imaging in binder alone. We recommend in those patients with either distracting injury or unable to assess, further imaging should be undertaken with the pelvic binder removed.

See pages 47 - 108 for financial disclosure information.

Does Transsacral-Transiliac Screw Fixation of an Uninjured Sacroiliac Joint Affect Pain and Functional Outcomes at 1-Year Follow-up?

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Purpose: Controversy exists regarding the effects of placement of a screw across an uninjured sacroiliac joint. Concerns including increased pain and decreased function have been suggested, while biomechanical benefits of transsacral-transiliac (TSTI) fixation have been documented when compared to iliosacral (IS) screws that stop short of the contralateral sacroiliac joint. Our null hypothesis is that placement of a TSTI screw across a contralateral uninjured sacroiliac joint in the first or second sacral segment will not show any difference with postoperative pain or patient-derived functional outcomes at 12 months follow-up.

Methods: All patients between ages 18-84 years who sustained injuries to the pelvic ring (AO/OTA 61 A, B, C) that were surgically treated between 2011 and 2013 at an academic Level I trauma center were identified for selection. Inclusion criteria were unilateral sacroiliac disruption or sacral fractures treated with standard IS screws and/or TSTI screws placed in the posterior ring. Exclusion criteria were bilateral posterior pelvic ring injuries, fixation with a device other than a screw, use of lumbopelvic fixation, previous pelvic or acetabular fractures, associated acetabular fractures, and ankylosing spondylitis. Outcomes were assessed at least 12 months after injury using the visual analog scale (VAS) pain scores for both posterior sacroiliac joints, Short Musculoskeletal Function Assessment (SMFA), and Majeed scores.

Results: 120 patients were identified that met inclusion and exclusion criteria. The study population was separated into two groups. Patients in group 1 were treated with TSTI screw fixation (n = 57) in the first and/or second sacral segments. Patients in group 2 were treated with IS screw fixation (n = 83) in the first and/or second sacral segments. Multiple attempts were made to contact every patient and 53 were available for follow-up at 12 months with 22 in group 1 and 31 in group 2 completing all outcome measures. There were no statistically significant differences between the groups with regard to age, gender, and ISS (all P values >0.33). No statistically significant differences were seen in VAS pain scores in the injured or uninjured sacroiliac joints, Majeed score, or SMFA function and bother indices between groups 1 and 2 (Table 1).

Conclusion: There were no statistically significant differences in VAS pain, SMFA bother and function indices, or Majeed scores between patients treated with TSTI or IS screw fixation for unilateral sacroiliac joint disruptions or sacral fractures. Placement of fixation across a contralateral, uninjured sacroiliac joint appear to have no significant clinical effect at 1 year post instrumentation.

Table 1. Patient derived outcome measures after screw fixation of the posterior pelvic ring

	VAS Injured	VAS Uninjured	Majeed	SMFA Function	SMFA Bother
Group1 TSTI Means (n-22)	2.95	2	79.3	29.7	29.7
Group 2 IS Means (n-31)	2.87	1.84	80.3	22.8	24.3
***p* values**	0.91	0.82	0.92	0.286	0.415

See pages 47 - 108 for financial disclosure information.

Evaluation and Effects of Perioperative Low Molecular-Weight Heparin Administration in Patients Treated with ORIF of the Acetabulum: Are Patients Getting Their Medicine?

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Purpose: The purpose of this study is to review the details and complications of enoxaparin administration for patients with acetabular fractures before undergoing surgical repair.

Methods: This is a large, retrospective multicenter study of consecutive patients at two large urban trauma centers. Patient data, injury data extracted from electronic medical records, and radiographs were reviewed. Patients were split into two groups depending on whether or not they received enoxaparin greater than or less than 12 hours before surgery order preoperatively. Data of primary interest included timing of enoxaparin administration, timing of surgery, operative blood loss, and complications related to both bleeding and early thromboembolic events. Patients studied included all adult patients with operative acetabular fractures at our trauma centers. Exclusion criteria included patients who had contraindications to enoxaparin and patients with other significant injuries treated in the same operative setting. We evaluated patient demographics, injury pattern, surgical approach, blood loss, thromboembolism (deep venous thrombosis [DVT] and pulmonary embolism [PE]), bleeding complications including secondary surgeries for hematoma evacuation or infection, and transfusion requirement.

Results: Of 336 patients included in the study, 316 (94%) received enoxaparin preoperatively. Only 43 (13.6%) of patients received enoxaparin within 12 hours of surgery, and the average time from prior enoxaparin dose to incision in all patients was 20.4 hours (range, 4.2 to 45.8 hours). In the group of patients who did not receive enoxaparin within 12 hours of surgery, 29 of 265 (15%) developed a DVT compared to 1 of 51 (0.5%) in those receiving the drug less than 12 hours before surgery (P <0.01). There was no increased risk of blood loss, transfusion, or bleeding complications for those patients receiving enoxaparin less than 12 hours before surgery. Of the 267 (84.4%) acetabular fracture patients taking enoxaparin preceding open reduction and internal fixation (ORIF) surgery who did not receive their immediate preoperative dose, it was ceased via a physician "stop" order (orthopaedic resident or other service) in 154 patients (56.9%, including 130 at the academic institution and 24 at the nonacademic center) or the medication was otherwise held (ie, last scheduled dose before surgery was not provided (by nursing and/or pharmacy without a physician order) in 113 patients (42.3%, including 70 at the nonacademic institution and 33 at the academic center).

Conclusion: We found that the vast majority of patients evaluated in this study received their last preoperative dose of enoxaparin between 8 and 36 hours before surgery. Patients who had effective enoxaparin up to the time of surgery (12 hours or less) experienced no DVTs or PEs, and did not appear at increased risk for bleeding or bleeding complications. Patients who had a gap in perioperative enoxaparin treatment did so apparently without direction from the acetabular surgeon; either other medical staff wrote a “stop” order or nursing and/ or pharmacy staff held the medication. The resulting variability in the timing of enoxaparin administration was not planned and appears to have left some patients untreated during this at-risk period.

See pages 47 - 108 for financial disclosure information.

Complications Are Reduced with Appropriate Resuscitation, Measured by Correction of Metabolic Acidosis

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Purpose: The optimal timing for definitive orthopaedic care is often unclear in polytrauma patients. The goal of this study was to prospectively assess the safety of the Early Appropriate Care (EAC) strategy, a previously published model that recommends definitive fixation within 36 hours if one of the following three parameters is met: lactate <4.0 mmol/L, pH = 7.25, or base excess (BE) = -5.5 mmol/L. EAC directs treatment to either damage control orthopaedics or early definitive fixation of axial and femoral fractures. We hypothesized that complications would occur with similar frequency in patients who had 1/3, 2/3, and 3/3 of the resuscitation parameters at time of surgery.

Methods: 335 patients were prospectively treated with EAC at a Level I trauma center, with 332/335 (99.1%) having fixation with at least one parameter at goal. Patients were grouped by the number of parameters at goal at the time of definitive fixation: 0/3, 1/3, 2/3, 3/3, or not all three labs drawn. Those in the 1/3 and 2/3 groups were combined into a separate group: incomplete parameter resuscitation (IPR), and complications were compared with patients who did have all (3/3) parameters at the time of surgery: full parameter resuscitation (FPR). Regression analysis was performed with ASA (American Society of Anesthesiologists), ISS, gender, and presence of various fractures for likelihood of developing a complication. Complications in the 6-month postoperative period were adjudicated by an independent multidisciplinary physician committee, and included infection, sepsis, PE/DVT (pulmonary embolism/deep vein thrombosis), renal failure, multiorgan failure, pneumonia, and ARDS (acute respiratory distress syndrome).

Results: 66 patients (19.7%) developed a total of 90 complications, which was lower than the 22.1% complication rate in a historical cohort of 1443 patients at our hospital. The complication rate in patients with only 1 EAC parameter at protocol goal at the time of surgery was 34.3%, which was higher than other groups (P <0.05). Patients with IPR did not have significantly more complications versus FPR (31.8% vs 22.6%, P = 0.078). Those with a femur fracture were less likely to receive FPR at the time of surgery (P = 0.034); however, they were also less likely to have a complication (25.7% vs 13.1%, P = 0.024). For patients with fractures other than the femur, FPR was not a significant predictor of complication rate, but showed important trends (29.2% vs 46.4%, P = 0.085). Regression analysis showed male gender and ISS to be independent predictors of a complication, while FPR was not a significant predictor of whether a complication would occur.

Conclusion: EAC guidelines are effective at reducing postoperative complications and offer a powerful subjective treatment algorithm dictating timing of care. Definitive fixation should proceed when at least one of the following criteria is met: lactate <4.0 mmol/L, pH >7.25, or base excess (BE) >-5.5 mmol/L. This study highlights important trends in the IPR and FPR groups, suggesting differences in resuscitation parameters may further guide care

in certain patients; additional study is needed. Therefore, we advocate for use of the existing protocol, while continuing research on these high-risk subgroups, the timing required for resuscitation, and other factors that may predict complications.

See pages 47 - 108 for financial disclosure information.

Pelvic Injury Predicts Shock Severity and Systemic Inflammation

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Background/Purpose: Multiply injured patients (MIPs) with pelvic injuries incur a substantial amount of mechanical and ischemic tissue damage. This population is at risk of significant blood loss and subsequent hemorrhagic shock (HS). Patients sustaining pelvic trauma have higher mortality rates and are more likely to require blood transfusion than MIPs without pelvic injury. Hemorrhage and tissue damage have been hypothesized to incite and propagate inflammation, which can manifest as the systemic inflammatory response syndrome (SIRS) and lead to multiple organ failure (MOF). The specific contribution of pelvic trauma to the overall injury complex and response to injury is unknown. We hypothesize the presence of a pelvic injury in MIPs will predict a higher degree of systemic inflammation, whole body tissue damage volume, shock, and organ dysfunction compared to MIPs without pelvic injury.

Methods: A retrospective analysis of MIPs (ISS >18) ages 18 to 65 years admitted to an ICU for a minimum of 7 days was conducted, identifying 77 consecutive patients. A cohort of patients with pelvic injury (Group 1, n = 39) was compared to a control group without pelvic injury (Group 2, n = 38). Trauma response was quantified by measuring daily SIRS scores (0-4) and averaging these values over the duration of the ICU stay. Daily Sequential Organ Functional Assessment (SOFA) scores (0-24) were measured and averaged over the ICU admission to assess organ dysfunction. Patient-specific whole body mechanical tissue damage was quantified using a novel index termed the Tissue Damage Volume Score (TDVS). TDVS is calculated by measuring the radius (and subsequent assumed spherical volume) of every injury detected on admission CT scans and radiographs (V = 4/3 pr3). Individual injuries were summed into a total TDVS score. Patient-specific hypoperfusion was quantified by measuring Shock Volume (SV), which is a composite value of the magnitude and duration of shock. SV is calculated by integrating sequential shock index (heart rate/systolic blood pressure) data points above a threshold of 0.9 for the first 48 hours after injury. A shock index >0.9 has been correlated with transfusion requirements, complications, and mortality. A Student t test was utilized to compare groups.

Results: Groups 1 and 2 were evenly matched with no demographic differences with respect to mean age (40 vs 38), gender (74% male, 26% female vs 79% male, 21% female), ISS (33 vs 30), ICU length of stay (15.1 days vs 15.6 days), body mass index (30.3 vs 30.4), and mortality (4 in each group). Pelvic injury patients had increased hypoperfusion compared to patients without pelvic injury. There was a trend toward more shock in the first 24 hours (SV = 11.45 Group 1 vs 8.76 Group 2, P = 0.08) and significantly more shock between 24 and 48 hours after injury with a 70% increase in hypoperfusion in pelvic injury patients in this time period (SV = 11.24 Group 1 vs 6.61 Group 2, P = 0.02). Patients sustaining pelvic injuries had 100% more mechanical tissue damage compared to patients without pelvic injury (TDVS = 1352 cm3 Group 1 vs 673 cm3 Group 2, P <0.01). Patients sustaining pelvic injuries had greater systemic inflammation with mean SIRS scores increasing by 25% (mean

SIRS = 2.31 Group 1 vs 1.88 Group 2, P <0.01). There was no difference in organ dysfunction between the groups (mean SOFA = 5.54 Group 1 vs 5.32 Group 2, P = 0.68).

Conclusion: This investigation demonstrated that MIPs with pelvic trauma had significantly more mechanical tissue damage and hypoperfusion than similarly injured MIPs without pelvic trauma. Interestingly, pelvic trauma appears to manifest in prolonged bleeding. Pelvic injury patients had significantly more shock volume in the second day after injury compared to MIPs without pelvic injury. The presence of a pelvic injury independently predicted higher levels of persistent inflammation after injury. However, greater inflammation did not extrapolate into higher degrees of organ dysfunction. This study applied two novel metrics that allow patient-specific measurements of injury to be investigated independently to determine how specific components of an injury complex manifest clinically. Future prospective studies should aim to further delineate how patient-specific injury characteristics and patient-specific response to injury predicts clinical trajectories.

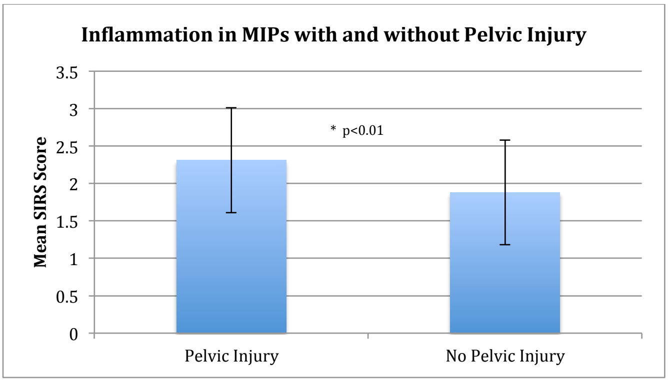

Figure 1. The presence of pelvic injury was associated with higher mean SIRS scores (p<0.01) compared to MIPs without pelvic injury.

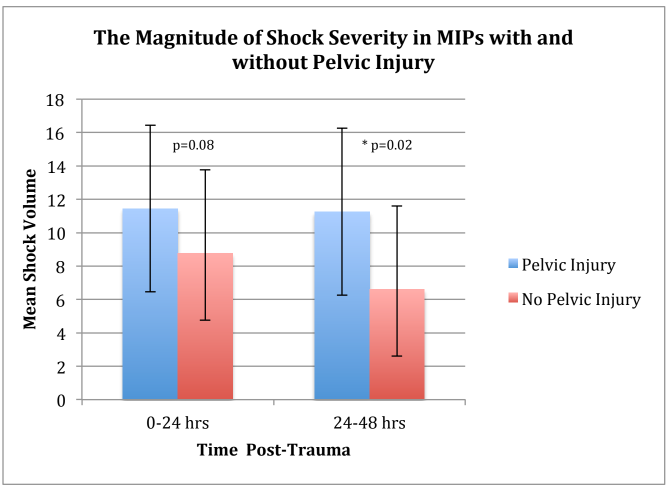

Figure 2. The presence of pelvic injury correlated with a greater magnitude and duration of shock 24-48 hours post-injury (p=0.02) compared to MIPs without pelvic injury and no statistical difference 0-24 hours post-trauma (p=0.08).

See pages 47 - 108 for financial disclosure information.

Management of Closed Diaphyseal Humerus Fractures in Polytrauma Patients

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Background/Purpose: The management of diaphyseal humerus fractures in the polytrauma patient varies widely. The only absolute indication for operative indications is an associated vascular injury; open fracture, floating shoulder, polytrauma, segmental fractures, and progressive radial nerve deficit all remain relative indications for surgical treatment. In addition, operative intervention is often considered with the theoretical goals of aiding with self-care, activities of daily living, and the earlier resumption of activities. The aim of this study was to compare outcomes of operative and nonoperative management of closed diaphyseal humerus fractures in polytraumatized patients. We hypothesized that operative management will improve patient mobility status and decrease time to union with a low complication rate when compared with nonoperative management.

Methods: A retrospective review of all patients with ISS >17 and diaphyseal humerus fractures treated at a Level I trauma center between January 1, 2006 and December 31, 2011 was performed. Medical records, radiographs, and trauma registry data were used to document patient demographics, injury characteristics, treatment intervention, complications, and outcome. Inclusion criteria included age = 18, AO/OTA fracture type 12 (humeral shaft fracture), and the presence of final outcome defined as healed fracture or nonunion requiring operative intervention. Patients were excluded if they had an ipsilateral proximal humerus fracture (including the anatomic neck and tuberosities), an ipsilateral intra-articular distal humerus fracture, or if the injury was open. Comparisons were then made between operative and nonoperative cohorts for injury characteristics, complications, and outcome. The Student t and chi-square tests were used to determine statistical difference between cohorts.

POSTER ABSTRACTS

Results: 288 patients with humeral shaft fractures were identified, 142 of whom had an ISS >17 (mean 32; range, 17-66). 27 patients were excluded, 17 for open injury, 4 for ipsilateral proximal humerus, and 6 for ipsilateral distal humerus fractures. 68 patients had final outcome documented, 38 in the operative group and 30 in the nonoperative group. There was no statistically significant difference between age, ISS (34 vs 30), or fracture type between the two cohorts. There was, however, a statistically significant higher incidence of associated orthopaedic injury, and more specifically, lower extremity injury in the group treated with operative intervention. Time to union in the operative group was 17 weeks, and in the nonoperative groups 14.5 weeks (P = 0.22). Time to resumption of unrestricted activity was 9 weeks in the operative group, and 12 weeks in the nonoperative cohort (P <0.05). Each group had 2 nonunions (5% vs 6.7%). Within the operative group, there were 2 postoperative radial nerve palsies (both recovered by 6 months), 1 deep infection, and 1 DVT (deep venous thrombosis). Within the nonoperative group, 4 (13%) patients failed to maintain their reduction, going on to ORIF (open reduction and internal fixation) within the first 2 weeks of injury. Complications in this group included 4 (13%) malunions (none of which showed any functional limitations, nor required reoperation), and 1 DVT.

Conclusion: Patients treated operatively were more likely to have lower extremity injuries ($P < 0.05$), with a significant number being bilateral. Operative treatment allowed resumption of unrestricted activity 3 weeks earlier ($P < 0.05$) but did not significantly change time to union or rate of nonunion. Closed management can be successful in this patient population with an acceptable complication rate in the appropriately selected patient.

See pages 47 - 108 for financial disclosure information.

Complications of Enoxaparin use in Orthopaedic Trauma Patients

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Background/Purpose: Orthopaedic trauma patients are susceptible to developing venous thromboembolic (VTE) complications. While VTE prophylaxis using low molecular-weight heparin (LMWH) such as enoxaparin has been shown to be effective, it is relatively costly compared to other chemoprophylactic agents, and the incidence of related wound and bleeding complications in this population is unknown. In arthoplasty literature, prolonged wound drainage associated with an increased risk of surgical site infection and hematoma have been identified as a reason to seek alternatives to these agents. Our hypothesis was that LMWH would be highly efficacious at preventing proximal deep vein thrombosis (DVT) and pulmonary embolism (PE) in orthopaedic trauma patients and have a low rate of bleeding complications.

Methods: A prospective trauma database was searched for all adult orthopaedic trauma patients presenting to a Level I urban trauma center over a 6-month period. CPT and ICD codes were used to identify all pelvic, acetabular and hip fractures, as well as all operatively treated upper and lower extremity fractures in adult patients (>18 years) with a minimum of 6-month follow-up. Only those patients receiving enoxaparin for VTE prophylaxis were included for analysis. Patients were excluded if they had a preexisting history of coagulopathy, had received confounding anticoagulation, or had isolated hand or foot injuries. Outcomes included the 6-month incidence of VTE events as well as major bleeding complications. VTE was defined as all confirmed proximal DVT and central and subsegmental PE). Based on cardiac and anticoagulation literature, major bleeding complications were defined as fatal bleeding into a critical organ, clinically overt bleed requiring >2 u transfusion following administration of LMWH. Additional wound complications including wound drainage or hematoma requiring reoperation, and the diagnosis of deep surgical site infection were also recorded. 832 orthopaedic trauma patients were identified for inclusion (mean age = 46.5 years, mean body mass index [BMI] = 28.3, mean ISS = 15.4). Of the 832 patients, 320 (38.5%) had upper extremity injuries, 672 (80.8%) had lower extremity injuries, and 116 (13.9%) had multiple extremity fractures. Acetabular, pelvic, and hip fractures were present in 315 patients, of whom 202 (64.1%) required operative treatment.

Results: The incidence of major bleeding complications following LMWH administration for VTE prophylaxis was 15.3% (95% confidence interval [CI] 12.8%-17.7%, n = 2 fatal bleeding into a critical organ, n = 88 clinically overt bleeds, n = 13 requiring reoperation for evacuation of hematoma, n = 48 deep surgical site infection). The incidence of VTE events was 3.6% (95% CI 2.3%-4.9%; n = 7 distal DVT, n = 10 proximal DVT, n = 5 subsegmental PE, n = 11 central PE). Independent risk factors associated with VTE events include serum lactate >5 within 6 hours of presentation, as well as lower extremity fractures at or proximal to the knee. Independent risk factors associated with major bleeding complications include increased patient age, elevated BMI, ISS >18, open fractures, and multiple extremity fractures.

Conclusion: We observed a low overall incidence of VTE and a particularly low rate of central PE (1.3%). Additionally, we observed a significant number of bleeding and wound complications associated with LMWH in this population. These data can be used to plan future randomized trials assessing alternative anticoagulants. Patient and injury characteristics associated with VTE and bleeding complications can give clinicians rough estimates of the complication profile in these patients when considering the use of these agents in orthopaedic trauma patients.

See pages 47 - 108 for financial disclosure information.

Posterior Bone Grafting for Tibial Nonunions

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Purpose: There is substantial controversy regarding the management of tibial shaft fracture nonunions. The Harmon posterolateral approach for tibial bone grafting dates from the Second World War, but has been neglected in the literature since that time. Our hypothesis was that posterolateral grafting of tibial shaft nonunions would have a high union rate with a low deep infection rate.

Methods: The study design was a retrospective case series of all patients treated with posterolateral (Harmon) bone grafting to treat tibial shaft fracture nonunion at a single statewide referral trauma center from 2004-2013. Procedures were typically done prone. Cultures were taken in the majority of the cases to assess for occult infection. A burr was used in each case to "dimple" decorticate the posterior tibia and medial and posterior fibula and then graft was applied in the tibiofibular interval and along the posterior face of the tibia. Graft choice and the use of bone morphogenetic protein (BMP) was at the discretion of the treating surgeon. Tibial bone defect length prior to grafting was measured across the points where the defect was the smallest.Our primary outcome variable was clinical union and our secondary outcome variables were any complication associated with the approach as well as infection requiring return to the operating room. Patients had at least 1 year of follow-up or until union.

Results: 59 patients met inclusion criteria with an average follow-up time of 23.5 months. The study group included patients who already had a history of deep surgical site infection prior to bone grafting (n = 17), established nonunions (n = 42), as well as impending nonunions associated with open fractures and bone gaps (n = 17). Overall, 44 patients (75%, 95% confidence interval [CI]: 63-86%) achieved clinical union with no further surgery. The mean interval to union was 9.9 months (range, 3-22). The mean bone defect size was 2.0 cm (range, 0.1-11 cm). 17 of 23 patients (74%) with defects larger than 2 cm, including defects up to 5.4 cm without infection, were successfully treated. Additionally two patients achieved union who were grafted at least 10 years following their initial injury. There were no complications noted to be associated with the approach and specifically no incidences of wound breakdown, vascular injury, or tendon injury. Eight patients (14%) had surgical site infection after the bone grafting procedure. Of the deep surgical site infections, seven of eight were in patients with prior infection or positive intraoperative cultures, so only one of 54 patients (1.9%) without history of infection had surgical site infection. Using intragroup comparisons or Fisher exact tests, the original fixation strategy (plate vs nail vs external fixation), fracture location, or defect size affected eventual union rates. Use of BMP showed a trend towards higher union rates despite a likely bias of using it in situations where the surgeon thought union was less likely (82% union, P = 0.14). A postoperative wound infection had a substantial negative effect on successful union without further surgery (infected: 25% union vs not infected: 82% union, P = 0.002).

Conclusion: Even in this relatively difficult patient cohort that included large bone gaps and patients with history of infection, union was achieved at a relatively high rate with one

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.

posterolateral bone graft procedure. The approach appears to be safe as there were no known complications specifically associated with the approach, and it appears to significantly reduce the risk of surgical site infection in the absence of prior infection. The approach seems to be a viable alternative for bone grafting of tibia fractures.

See pages 47 - 108 for financial disclosure information.

The Power of a Swab: Can Preoperative Nasal Culture Predict Complications or Outcomes Following Repair of Fracture Nonunion?

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Background/Purpose: Much has been published about the risks for infection and the surgical complications associated with patients who carry Staphylococcus aureus. The purpose of this study is to determine if nasal swabbing for methicillin-resistant S. aureus (MRSA) and methicillin-sensitive S. aureus (MSSA) bacterial carriage can predict operating room culture, function, and/or outcome after fracture nonunion surgery.

Methods: 62 patients undergoing surgery for fracture nonunion were prospectively followed. Prior to intervention, patients were nasally swabbed for carriage of MRSA and MSSA and subsequently treated by an orthopaedic surgeon blind to carrier status. Preoperative lab data and length of hospital stay (LOS) at the time of surgery were documented. Data analyses were performed using grouped MRSA and MSSA carriers (Staphylococcus carriers [SCs]) versus noncarriers. Patient follow-up was performed at regular intervals to evaluate for wound complications including culture of S. aureus, antibiotic usage, pain, and Short Musculoskeletal Function Assessment (SMFA) scores. Outcomes analyzed also included time to healing, need for additional surgery, and persistent mal/nonunion.

Results: The nonunion sample included tibia, femur, humerus, clavicle, and forearm fractures. 26% of patients were identified as MSSA carriers while an additional 6.5% carried MRSA. Average preoperative white blood cell counts, ESR (erythrocyte sedimentation rate) and CRP (C-reactive protein) values did not differ between SCs and noncarriers. Hospital LOS was similar between groups. Carriers were just as likely as noncarriers to culture positively for any pathogen at the time of surgical intervention. However, SCs were three times as likely as noncarriers to grow S. aureus (14.3% vs 4.7%; $P = 0.3$). Postoperative wound complications, antibiotic use, pain at follow-up, and progression to healing did not differ between groups. Mean time to healing was similar at 6.1 (±3.5) months among SCs and 6.4 (±4.5) months among noncarriers. Postoperative follow-up of at least 12 months was available on 91% of patients. Functional scores were significantly worse in SCs at 3 months (SMFA indices of function, bothersome, emotion, and mobility; $P = 0.02$) with significantly worse mobility reported at 6 and 12 months ($P < 0.05$).

Conclusion: Preoperative nasal swabbing for S. aureus is a simple and noninvasive diagnostic tool with significant prognostic implications in patients undergoing fracture nonunion surgery. This study demonstrated poorer postoperative functional outcomes in patients who carried MRSA or MSSA with sustained losses in mobility up to a year after nonunion surgery. Identification of patients at risk for developing postoperative complications has significant implications for HCAHPS (Hospital Consumer Assessment of Healthcare Providers and Systems) scores and health-care quality metrics.

Indications and Timing of Tracheostomy After Cervical Spine Injury: Implications for Hospital Stay and Recovery

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Purpose: The purpose of this study was to characterize the relationship between timing of tracheostomy after cervical spine injuries and patient outcomes. We hypothesized that without a formal protocol to determine timing of tracheostomy, patients who were more severely injured would have tracheostomy earlier. We further hypothesized that in spite of greater injury in such patients, early tracheostomy would not be associated with complications; rather, it would shorten mechanical ventilation time and hospital stay.

Methods: 446 patients treated at a Level I trauma center for fractures and/or ligamentous cervical spine injury over 77 months were identified. 44 had insufficient records. Information including age, gender, ISS, Glasgow Coma Scale (GCS), associated injuries, length of stay (LOS), and mortality was included for the remaining 402 patients.

Results: 62 patients (15.4%) underwent tracheostomy. They had higher ISS (19.3 vs 10.6, P <0.001), ASIA (American Spinal Injury Association) score (1-5 = E-A: 3.6 ± 1.5 vs 1.5 ± 0.88, P <0.001), and lower GCS (11.6 vs 13.8, P = 0.001). Patients who received tracheostomy were more likely to have ligamentous injury (53.3% vs 34.6%, P = 0.02), spinal cord injury (SCI) (80.0% vs 49.3%, P <0.001), and chest injury (AIS [Abbreviated Injury Scale] Chest: 0.97 vs 0.39, P <0.01). Tracheostomy was associated with longer LOS (23.9 vs 6.85, P <0.001), and these patients spent a mean 7 days intubated before tracheostomy (7.37 vs 1.2, P <0.001). Survival rate was no different versus non-tracheostomy patients (89.1% vs 83.9%). Tracheostomy was performed within 7 days after injury in 27 patients (46.6%, defined as early). They had lower GCS (8.96 vs 13.5, P <0.001), but were no different in age, ISS, ASIA, and severity of chest injury. Early versus late patients were no different in LOS (23.0 vs 25.7 days, P = 0.43), tracheostomy days (42.3 vs 49.2, P = 0.427), or survival (91% vs 88%). Analysis of the time from injury to tracheostomy revealed that in spite of increasing GCS scores (R2 = 0.991), patients with late tracheostomy tended to have longer LOS (R2 = 0.84125), but the sample was underpowered to show significance.

Conclusion: Protocols regarding indications and timing for tracheostomy have not been well developed. This population is especially likely to require long-term mechanical ventilation due to SCI and frequent chest injury. In spite of greater injury burden, tracheostomy patients had similar mortality rate as the general population. Our early tracheostomy patients had lower GCS. Linear regression shows correlation between delaying tracheostomy and increasing LOS, but further study of a larger group of patients is needed.

POSTER ABSTRACTS

See pages 47 - 108 for financial disclosure information.

Percutaneous Lumbopelvic Fixation for Sacral Fractures with Spinopelvic Dissociation

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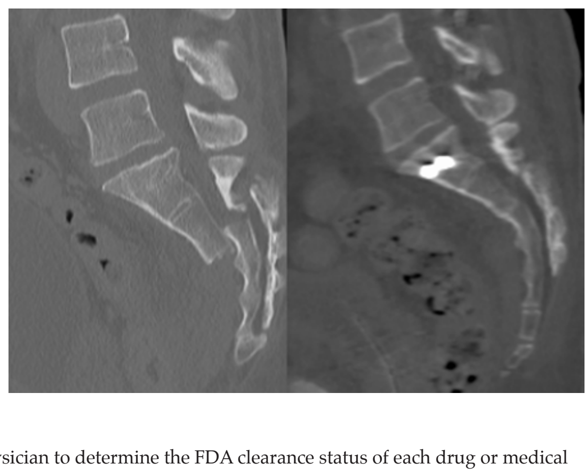
Background/Purpose: Sacral fractures with spinopelvic dissociation patterns are highly unstable injuries. Reestablishing the anatomic relationship of the pelvis to the axial spine and achieving mechanical stability, while preserving neurologic function, are the main treatment goals. Lumbopelvic fixation is typically performed through a single posterior extensile midline incision from L4 to the pelvis. Surgery can be lengthy with major blood loss, and associated with wound complications. In an effort to minimize the morbidity of surgery while achieving stable fixation, we developed a percutaneous lumbopelvic fixation technique. The purpose of this study is to determine the outcomes and complications of percutaneous lumbopelvic fixation in the treatment of highly unstable sacral fractures with spinopelvic dissociation patterns.

Methods: Between March 2008 and August 2014, 15 consecutive patients with bilateral vertical sacral fractures and a transverse fracture (U or H-type pattern) resulting in spinopelvic dissociation were treated with percutaneous lumbopelvic fixation using lumbar L4 and L5 pedicle screws connected to iliac screws with rods. No open surgeries for this injury pattern were performed during this time. Surgery was performed through separate paired parasagittal incisions under fluoroscopic guidance. Data were collected prospectively including blood loss, fluoroscopy time, screw accuracy, wound complications, neurologic status including bowel and bladder function, instrumentation failure, fracture healing, and patient functional status using established outcomes questionnaires.

Results: Clinical follow-up in 13 patients who had surgery more than 1 year prior to this report averaged 709 days and radiographic follow-up averaged 520 days. Across all 15 patients surgical duration averaged 2 hours 21 minutes and blood loss averaged 192 mL, and there was 1 deep wound infection. Postoperative CT scans included 94 screws and showed an intraosseous screw accuracy rate of 98%, with 2 screws revealed to have minor cortical breaches that were inconsequential. Fracture reductions were attempted in 5 patients and achieved in 3, including anatomic reduction of a completely displaced and shortened fracture (traumatic spondyloptosis) as shown in Figure 1. Patients stood on average 8 days after surgery. All fractures healed. One patient had not regained normal bladder function when he was lost to follow-up at 135 days, but he also had a severe lumbar spine injury. One patient developed postoperative weakness in bilateral tibialis anterior muscle groups that could not be explained on CT or MRI.



This most likely represented a stretch neurapraxia, and there was full neurologic recovery. No other patients developed neurogenic bladder dysfunction as a result of their injury. There were no instances of screw loosening or instrumentation failure. At the time of this report, instrumentation was electively removed in 5 patients without complication. The Short Form Health Survey SF-12v2 average Physical Component Summary score was 43 with a range of 26-51 (population average is 50) and the Mental Component Summary score was 54 with a range of 46-62 (population average is 50). The average Oswestry Disability Index score was 17% with a range of 0%-44% (0%-20% indicates minimal disability, 20%-40% indicates moderate disability, and 40%-60% indicates severe disability).

Conclusion: Sacral fractures with spinopelvic dissociation patterns are severe injuries. This is the first reported series of patients treated with a percutaneous technique. Percutaneous lumbopelvic instrumentation can be performed safely with limited blood loss and within a reasonable surgical duration, theoretically minimizing the physiological burden of surgery in these severely injured patients. Patients can be mobilized immediately without restriction. The known problem of wound complications with these types of injuries, however, is not fully solved. Fracture manipulation can be performed as evidenced by anatomic reduction in a case of traumatic spondyloptosis, but further technique refinement is necessary in order to reliably and safely reduce these fractures. Percutaneous lumbopelvic fixation is a safe and effective option for stabilization of highly unstable sacral fracture patterns with associated spinopelvic dissociation.

See pages 47 - 108 for financial disclosure information.

Risk Factors for Pulmonary Complications Among Patients with Operative Spine Fractures

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Purpose: Cervical and thoracolumbar fractures are relatively common injuries after high-energy trauma, and most patients have injuries to other body systems. The spinal column's intimate association with multiple vital structures contributes to frequent complications in prior reports. The purpose of this study is to identify risk factors for complications among patients with operative spinal injury.

Methods: Data were collected for 305 consecutive adult patients who had fixation of cervical (n = 138) or thoracolumbar (n = 181) fractures (33 patients with operative thoracic spine injury at or proximal to T6, and 148 patients with injury inferior to T6). 14 had fixation of both cervical and thoracolumbar fractures. 102 (33%) had concurrent spinal cord injury (SCI). Patient and injury features were characterized, treatment and hospitalization details were recorded, and complications including pneumonia, acute respiratory distress syndrome (ARDS), organ failure, infections, sepsis, and thrombotic events were noted.

Results: 64 patients (21%) developed 87 complications, with complications occurring in 25% of patients with fractures at or proximal to T6 versus 17% for distal thoracolumbar fractures (P = 0.12). Pulmonary complications accounted for 46/87 (53%) of complications, and occurred in 42 (21 cervical and 21 thoracolumbar) patients with pneumonia (n = 35) and ARDS (n = 9). After multiple logistic regression pulmonary complications were associated with SCI (odds ratio [OR] 6.8, P = 0.001), history of tobacco use (OR 3.1, P = P 0.02), higher American Society of Anesthesiologists (ASA) classification (mean 3.3 vs 2.8, OR 2.6, P = 0.01), and lower Glasgow Coma Score (GCS; mean 9.6 vs 12.8, OR 0.9, P = 0.03). Severe chest injury (Abbreviated Injury Scale [AIS] = 2) was associated with pulmonary complications (55% vs 13%, P <0.001). Patients with thoracic fractures at or proximal to T6 had a rate of 22% for pulmonary complications, versus 8.8% for lower thoracic fractures (P = 0.032). Among thoracolumbar patients, pulmonary complications were associated with SCI (OR 4.5, P = 0.047) and tobacco use (OR 4.3, P = 0.02). Among patients with cervical injury, pulmonary complications were associated with SCI (OR 7.3, P = 0.01), chest injury (OR 6.5, P = 0.03), ASA (OR 4.7, P = 0.002), and ISS (OR 1.1, P = 0.049), but not tobacco use (OR 2.0, P = 0.17). Overall, pulmonary complications were associated with longer length of stay (LOS; mean 22.1 vs 9.5 days, all P <0.001), longer intensive care unit LOS (mean 20.4 vs 9.5 days, all P <0.001), and more time on mechanical ventilation (mean 13.8 vs 3.7 days, all P <0.001).

Conclusion: We identified several risk factors for pulmonary complications, including tobacco use, GCS, ASA, and SCI, and severe chest injury. Pulmonary complications occurred most often in patients with upper thoracic injury and were associated with substantial morbidity in terms of LOS and mechanical ventilation times, which translate into greater costs of care. Future studies with larger sample size will be able to further elucidate risk factors based on more specific injury characteristics. Mitigation of risks through treatment strategies and modifiable factors is desirable.

Spinal Fracture Patterns in Patients with Ankylosing Spondylitis

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Purpose: Patients with ankylosing spondylitis are susceptible to fractures of the spinal column, even from minimal trauma. However, the literature describing patients with ankylosing spondylitis and spinal fractures consists largely of case reports and small case series. The purpose of this study is to characterize fractures of the ankylotic spine, including the patient population, locations of fracture, associated spinal cord injuries, and adverse events in a large, nationally representative sample.

Methods: All patients with a diagnosis of ankylosing spondylitis with a primary or secondary diagnosis of fracture of the spinal column admitted between 2005 and 2011 were identified in the Nationwide Inpatient Sample (NIS). Modified Charlson comorbidity index (CCI) was calculated for each patient. Patient demographics, fracture types, and complications were characterized with descriptive statistics.

Results: A total of 939 patients with ankylosing spondylitis admitted with a spinal fracture were identified in NIS. The average age was 68.4 ± 14.7 years and 798 (85%) of patients were male. Modified CCI scores of 0, 1, 2, 3, or 4 or more were distributed approximately evenly (20% each). Table 1 details the injury patterns in these patients. The distribution of fractures in each spine region followed a gradient from superior to inferior. Cervical fractures were the most common (53.0%), followed by thoracic (41.9%), lumbar (18.2%), and sacral (1.5%). Spinal cord injury was present in 21.1% of cases. The proportion of fractures involving spinal cord injury also followed a gradient from superior to inferior. Cervical fractures involved spinal cord injury in 25.3% of cases and 16.0% of thoracic fractures involved spinal cord injury, while no fractures in the lumbosacral spine were associated with spinal cord injury. Fractures involving more than one region of the spine occurred in 15.2% of patients. Adverse events occurred in 29.4% of patients. 6.6% of patients died during their admission. The most common adverse events were urinary tract infection (9.6%), intubation (8.5%), acute kidney injury (7.0%), and pneumonia (6.3%).

Conclusion: The distribution of spinal fractures in the ankylotic spine follows a gradient from cephalad to caudad, as does the association with spinal cord injury. In fact, more than one fifth of patients had spinal cord injury associated with their fracture, the majority of which were cervical. It is very important to note that more than 15% of patients had fractures in more than one region of the spine. These results emphasize the need to evaluate the entire spine in ankylosing spondylitis patients with possible spinal fracture. Further, morbidity is high in the ankylosing spondylitis population with spinal fracture, and mortality was 6.6% during their hospitalization. These results provide clinicians with a better understanding of the distribution, associated injuries, and the high morbidity and mortality of fractures in the ankylosed spine.

See pages 47 - 108 for financial disclosure information.

Table 1. Fracture types in ankylosing spondylitis patients.

Fracture Type	No.	%
Total	939	100%
Region		
Cervical	498	53.0%
Thoracic	393	41.9%
Lumbar	171	18.2%
Sacral	14	1.5%
With Spinal Cord Injury	198	21.1%
Cervical	137	14.6%
Thoracic	63	6.7%
Lumbar	0	0%
Sacral	0	0%
Multiregion Injuries	143	15.2%
Cervical and Thoracic	71	7.6%
Cervical and Lumbar	22	2.3%
Thoracic and Lumbar	50	5.3%
Cervical, Thoracic and Lumbar	10	1.1%

Dynamic Screw Configuration and Fibular Osteotomy Decrease Healing Time in Tibia Nonunion Exchange Nailing

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Background/Purpose: Intramedullary (IM) nailing is the most common method for surgical management of tibial fractures, yet nonunion still occurs in up to 16% of patients. Several studies have shown that reamed tibial exchange nailing is an acceptable technique to manage tibial nonunions. Some IM nails can be locked in a static or dynamic configuration depending on the shape of the screw hole. By placing the proximal screws in a dynamic configuration, fracture impaction may be possible while still controlling rotation and limiting shortening. In some cases, the fibula may heal prior to the tibia and keep the tibia in a distracted position, necessitating a fibular osteotomy. The study hypothesis is that a dynamic screw configuration will facilitate union faster than a static configuration. Additionally, the use of a fibular osteotomy in conjunction with exchange nailing will also facilitate faster time to union.

Methods: A retrospective chart review was conducted at six participating medical centers to identify patients with tibia fractures treated with IM nails that progressed to nonunion. Those who were subsequently treated with an exchange nail procedure that went on to union were included in the study. Patients who qualified for the study were characterized based on the configuration of the screws in their IM nailing procedures and whether they had a fibular osteotomy. The primary outcomes were to analyze time to heal from the date of the exchange nail for the various configurations. Patients who underwent more than one exchange nail procedure were included in the study population, but direct comparisons were only made between patients with one exchange nail procedure.

Results: 87 patients were identified, of whom 80 had only one exchange nail procedure. Fractures were classified as open (82%), closed (15%), or unknown (2%). Patients with dynamically locked nails proceeded to union 7 months after revision surgery compared to 8 months for those with statically locked nails. Patients with a fibular osteotomy proceeded to union 2.7 months faster than those without a fibular osteotomy.

Conclusion: Patients who had a dynamic screw configuration for exchange nailing had improved time to union compared with static screws. Patients who underwent fibular osteotomy proceeded to union faster than those without an osteotomy.

See pages 47 - 108 for financial disclosure information.

Baseline RUST Score Predicts Success with Operative Treatment of Tibial Nonunion

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Purpose: Tibial nonunion is a significant cause of patient morbidity. The Radiographic Union Score for Tibial Fractures (RUST) has been demonstrated to be a reliable method to determine degree of healing of acute tibial fractures. It has been shown to correlate with patient function and predict whether patients will develop nonunion 3 months following tibia fracture. No data exist as to whether the RUST score can predict similar success in patients with established nonunion.

Methods: 103 patients who were treated by a single surgeon for a diagnosis of tibial nonunion were reviewed. All patients underwent surgical repair of a tibial nonunion and were followed at regular intervals for 12 months with physical and radiographic examination. Radiographs obtained before revision surgery were reviewed and scored using the RUST scoring system by two fellowship-trained traumatologists blinded to time to union. Differences in RUST score were averaged. Postoperative time to union was determined by clinical and radiographic measures. A Spearman rank-order correlation was run to assess the relationship between preoperative RUST score and postoperative time to union in patients with tibial nonunion. A binomial logistic regression was run to determine the effect of RUST score on the likelihood that the patient would develop a persistent nonunion.

Results: 103 patients with tibial nonunion were identified. 5 were lost to follow-up. Preoperative plain radiographs were available for 82 of the patients (84%) that had follow-up. All patients without preoperative radiographs went on to union. Two patients were not eligible to be scored by the RUST system. 74 of 80 patients with tibial nonunion went on to heal. The mean preoperative RUST score for healed patients was 7.6 (standard deviation [SD] 1.4) with a mean time to union of 7.4 months (SD 4.6). Six patients failed to heal. Mean RUST score for patients who did not heal was 6 (SD 2.2). Preoperative RUST score was a statistically significant predictor of failure to unite ($P = 0.025$, Exp(B) = 0.530, 95% CI [confidence interval] Exp(B) 0.305 to 0.922), demonstrating an increased RUST score is associated with a reduction in the likelihood of developing persistent nonunion. Spearman rank-order correlation showed a negative correlation between preoperative RUST score and postoperative time to union ($r_s = -0.244$, $P = 0.039$).

Conclusion: A higher baseline RUST score in a tibial nonunion patient is associated with successful union ultimately. The baseline RUST score, however, demonstrated a negligible negative correlation with postoperative time to union. Preoperative RUST score may allow physicians to guide patient expectations for healing a tibial nonunion as it does an acute tibial fracture.

Active Smoking Is a Risk Factor for Greater Pain Following Nonunion Repair of the Extremities

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Purpose: Nonunion of long bone fractures is a serious complication for many patients. The majority of patients who undergo treatment for long bone nonunion go on to heal with recovery of function and pain relief. Unfortunately, pain relief can be complex in these patient,s with many risk factors of postoperative pain yet to be identified. The purpose of this study is to elucidate factors associated with continued pain following long bone nonunion surgery and offer better pain control advice to patients.

Methods: All patients with long bone nonunion presenting to a one of three orthopaedic traumatologists were enrolled in a prospective registry. Enrolled patients were followed at regular intervals for 12 months using the Short Musculoskeletal Function Assessment (SMFA), visual analog scale (VAS), physical examination, and radiographic examination. The registry was reviewed to identify patients with a tibial or femoral nonunion that went on to union with complete follow-up. A Friedman test was conducted to determine differences in pain level preoperatively and postoperatively. Univariate analyses were conducted to identify patient characteristics significantly associated with postoperative pain using a significance cutoff of $P = 0.1$. Significant factors were included in multivariate linear regressions to identify risk factors for pain 3 months, 6 months, and 12 months after nonunion surgery.

Results: 91 patients with tibial or femoral nonunion who went on to union and had complete follow-up were identified. 57 patients (63%) had tibial nonunion. 34 patients (37%) had femoral nonunion. A Friedman test revealed mean pain score decreased significantly by 3 months postoperatively ($P < 0.0005$). Univariate analyses demonstrated age ($P = 0.016$), days from injury to nonunion surgery at our institution ($P = 0.067$), smoking status ($P < 0.0005$), wound status at time of injury ($P = 0.085$), anesthesia ($P = 0.045$), and nonunion location in the bone ($P = 0.047$) were significantly associated with postoperative pain in at least one time point postoperatively. These were included in multivariate regressions that revealed nonunion location ($P = 0.035$) was predictive of pain 3 months postoperatively, smoking status ($P < 0.0005$) was predictive of pain 3 months ($P = 0.012$) and 6 months ($P < 0.0005$) postoperatively, and days from injury to nonunion surgery at our institution was predictive of pain 6 months ($P = 0.024$) and 12 months ($P = 0.004$) postoperatively.

Conclusion: Healed patients have improvement in pain levels after nonunion surgery of the tibia and femur. Orthopaedic surgeons should stress smoking cessation programs and minimize delay to nonunion surgery, in order to maximize relief of pain in this patient cohort.

See pages 47 - 108 for financial disclosure information.

Validation for the "Six Hour Rule" for the Severe Open Tibia Fracture

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Purpose/Background: The "six hour rule" serves as the accepted time frame for the initial irrigation and debridement to minimize septic complications after severe open tibia fractures. This study examined the validity of this traditional care paradigm in Gustilo-Anderson grade IIIB open tibia shaft fractures, which represent a subset of open fractures in which greater infection rates are expected.

Methods: This is a retrospective cohort study of grade IIIB open tibial shaft fractures treated at 2 Level I trauma centers from 2001-2013 by 5 attending surgeons. Fractures were treated initially with serial irrigation and debridement and vacuum-assisted closure device, and definitively with intramedullary nail, plate and screw fixation, or external fixator. Mean follow-up was 15 months (range, 2 to 61 months). Time to surgery was defined as time from arrival to the start of the case. Transfers were excluded as the time spent at outside hospitals could not be quantified. Data were analyzed using SPSS with Pearson chi-squared test.

Results: A total of 77 grade IIIB open tibial shaft fractures presented in the 13-year period; 15 transfers were excluded, 10 cases were excluded due to lack of follow-up, 2 due to death, 2 due to insufficient data in record, and 1 due to conversion to below the knee amputation. Of the remaining 47 cases, 77% underwent initial debridement within 6 hours. Mean patient age was 38 years (range, 17-67 years); mean time to debridement was 5 hours 39 minutes (range, 51 minutes-43 hours). Reoperation for infection was required in 5.6% of cases treated within 6 hours and 36.4% of cases treated after 6 hours. The exact 2-sided significance of the Pearson chi-squared test comparing infection rate between these groups was P = 0.021 with an odds ratio of 6.1.

Conclusion: Initial open fracture care within 6 hours of admission significantly reduces the infection rate in grade IIIB open tibial shaft fractures. Cases that are delayed more than 6 hours have an odds ratio of infection of 6.1 relative to those that are not.

Surgical Approaches to Intramedullary Nailing of the Tibia: Comparative Analysis of Knee Pain and Functional Outcomes

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Background/Purpose: Postoperative knee pain is common following intramedullary nailing of the tibia, although the exact source is unclear and controversial. Historically, patellar tendon splitting and medial parapatellar approaches have been used most frequently, and both have resulted in similarly high rates of knee pain. Alternative surgical approaches have recently been described that place the knee in a semi-extended position, simplifying patient positioning, fracture reduction, fluoroscopic assessment, and implant insertion. Specifically, the semi-extended lateral parapatellar approach provides these and avoids violation of the knee joint capsule. The semi-extended lateral parapatellar approach is relatively novel, and therefore a comparison to a historical standard is warranted. We hypothesized that in a direct comparison of outcomes between patients having undergone intramedullary nailing of the tibia, patients treated with this approach would have decreased knee pain and better knee function compared to knee hyperflexion approaches (medial parapatellar and tendon splitting).

Methods: A trauma patient database from a single Level I center was queried for patients who underwent tibial intramedullary nailing for acute fracture between 2009 and 2013. Patients were contacted via telephone and surveyed for knee pain severity (NRS [Numeric Rating Scale] of 1 to 10) and location, and completion of the Lysholm Knee Scale (LKS). Data were compared between the semi-extended lateral parapatellar, medial parapatellar, and tendon-splitting groups regarding knee pain severity, knee pain location, total LKS, and individual knee function scores from the Lysholm questionnaire. Pre-hoc power analysis determined an adequate sample size to detect clinically significant differences in Lysholm score (n = 34). Post-hoc analysis was done using one-way ANOVA (analysis of variance) with a significance value set at $P < 0.05$.

Results: Each group consisted of 34 patients. Comparison between the 3 surgical approaches regarding knee pain severity found no significant difference ($P = 0.69$), with the following average ratings: semi-extended lateral parapatellar (3.26), tendon splitting (3.59), and medial parapatellar (3.63). Analysis also found no significant difference between the 3 groups in total LKS score ($P = 0.33$), with the following average sums: semi-extended lateral parapatellar (75.97), medial parapatellar (77.53), and tendon-splitting (81.68). Individual knee function scores from the LKS questionnaire were similar between the 3 groups, except for limping, which was significantly different, with medial patellar being significantly worse ($P = 0.04$). There was no significant difference in knee pain location between the 3 patient groups ($P = 0.45$).

Conclusion: In this adequately powered study, at minimum 1-year follow-up there were no statistically significant differences between any of the 3 approaches in knee pain severity, location, or overall knee function as determined by the LKS. The three were significantly different in postoperative limping, with medial parapatellar having the lowest LKS score. The semi-extended lateral parapatellar approach vastly simplifies many technical aspects of tibial nailing compared to those that involve hyperflexion of the knee, and does not involve violation of or instrumentation through the knee joint.

See pages 47 - 108 for financial disclosure information.

Risk Factors for Wound Failure After Primary Closure of Type IIIA Open Tibia Fractures

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Purpose: Previous studies have reported high complication rates with treatment of Gustilo-Anderson type IIIA open tibia fractures; however, little data exist to assist clinicians in predicting the likelihood of complications for these severe injuries after attempted primary skin closure. Our hypothesis is that risk factors can be identified that increase the likelihood of subsequent wound failure requiring flap coverage following primary closure of type IIIA open tibia fractures.

Methods: A retrospective review of all acute open fractures of the tibia (plateau, shaft, or pilon) classified as type IIIA that underwent primary closure at a single Level I trauma center from 2005 to 2013 yielded 278 patients. Patient, injury, and treatment characteristics were abstracted from the medical record. The primary outcome measure was any complication requiring unplanned surgical treatment of the study injury resulting in flap coverage. Bivariate and multiple variable regression techniques were used to identify independent predictors of complications while adjusting for multiple confounders.

Results: 55 patients (20%) ultimately underwent flap coverage to obtain wound closure for complication after an attempt at primary closure. Patient who required a flap experienced a 42% complication rate (23/55) after delayed flap coverage. The limb salvage rate was 95% for the study population. Three statistically significant predictors of complications after primary closure were identified: >3 debridements prior to closure (odds ratio [OR] 29.8, P <0.001, confidence interval [CI] 5.9-150.1), wound closure >2 days after injury (OR 9.8, P = 0.01, CI 1.6-60.2), and use of external fixator for more than 14 days (OR 7.3, P = 0.01, CI 1.6-34.6). Patients who had >3 debridements prior to closure had a 70.7% chance of having a complication resulting in a flap (29/41) compared with only 6.8% of those who had 2 or less debridements (14/205, P <0.001). A number of variables were tested and found not to be risk factors for complications including age, sex, body mass index, American Society of Anesthesiologists score, use of negative-pressure wound therapy, fracture location, fracture severity, and timing of initial debridement.

Conclusion: Analysis of this large cohort of type IIIA open tibia fractures identified three strong risk factors for complication after primary closure including number of debridements, wound closure after 2 days, and greater than 14 days of external fixation. It can be argued that all of these risk factors are markers for increased severity of the soft-tissue injury and therefore beyond the surgeon's control. However, noting that wounds requiring >3 debridements failed 70.7% of the time after closure, surgeons should be cautious in closing the wound primarily in this situation. Alternative approaches, such as flap coverage, should be considered in these more severe cases.

Intramedullary Devices for Diaphyseal Femur and Tibia Fractures:
A Comparison Analysis of Different Generations of Intramedullary Fixation

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Purpose: Reamed intramedullary fixation of closed diaphyseal femur and tibia fractures has become the gold standard of treatment as nail design has improved. New elements have been added to intramedullary nail (IMN) designs including multiple locking hole options to increase the versatility of the nail for treatment of more complex fractures. However, these new elements greatly increase the cost of the implant. The goal of this study was to compare two generations of IMNs to see if the increased cost is justified by differences in healing rates or complications in diaphyseal lower extremity fractures.

Methods: We retrospectively reviewed 102 consecutive closed diaphyseal femur and tibia fractures (AO/OTA classification 32 and 42) from 2008 through 2013 treated with one of two generations of IMN by one manufacturer (Group A with traditional uniplanar locking bolts and Group B with multiplanar with fixed-angle locking options). Primary outcomes were fracture healing and implant-associated complications. The published list price was used to determine cost of the implants.

Results: There were 50 IMNs in Group A and 52 in Group B. There were no significant differences between the number of tibias and femurs between groups. There were no differences in the OTA fracture classification between groups. Time to healing was not significant between groups (3.8 months and 3.6 months, respectively). There were 4 delayed unions in Group A and 7 in Group B. Two nonunions were observed in Group A and 5 in Group B. There were no broken nails. A broken/backed-out screw was observed in 5 cases in Group A and in 4 cases in Group B. All-cause reoperations occurred in 10 patients in Group A and 9 patients in Group B. The newer generation nails cost between 34% (retrograde femur), 56% (antegrade femur), and 49% (tibia) more than the earlier generation nails.

Conclusion: The use of the newer generation nails for diaphyseal fracture patterns may not be necessary based upon the data we have analyzed. A protocol for use of these more expensive devices could be developed so they are reserved for more complex or unstable fractures that extend into the metadiaphysis, where the multiplanar and fixed-angle locking options may be of benefit.

See pages 47 - 108 for financial disclosure information.

Semi-Extended Versus Standard Nailing for Treatment of Distal Third Tibia Fractures: A Multicenter Study

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Background/Purpose: Originally described for proximal tibia fractures by Tornetta et al in 1996, semi-extended nailing is gaining in popularity. Recent reports on semi-extended and suprapatellar nailing are expanding its indications to more distal tibia fractures. Malalignment in distal third tibia fractures treated with standard nailing has been reported in up to 29% of fractures. The semi-extended technique (performed with a partial medial parapatellar arthrotomy with the knee in 15-30° of flexion) allows the surgeon to reduce the fracture, obtain radiographs, and perform the nailing procedure without manipulating the leg. This purpose of this study is to evaluate the radiographic outcomes of distal tibia fractures treated with semi-extended nailing (knee flexion of 30°) compared to those treated with standard nailing in a hyperflexed (>90°) position.

Methods: After approval from the IRB, patients were identified using a billing database, and a retrospective chart review of those patients who sustained a distal tibia fracture and were treated with intramedullary nailing from November 2007 until January 2014 was completed. Surgeries were performed at two academic trauma centers. Multiple surgeons performed both the standard and semi-extended nailing procedures. Fractures were classified according the AO/OTA classification type 43. The primary outcome measure was alignment at union. All patients were followed for at least 1 year. Radiographic outcomes at final follow up were measured on AP and lateral full-length tibia-fibula radiographs at fracture union by an independent orthopaedic radiologist blinded to the treatment. Malunion was defined as angulation >5° in any plane. A two-tailed Student t test was used to evaluate significance between the mean angulation at union between the two groups. A chi-squared test was used to evaluate significance between the number of patients with malaligned fractures in each group. Significance was set at P = 0.05.

Results: There were 39 patients treated with semi-extended nailing and 48 patients treated with standard nailing technique. 12 patients in both groups had intra-articular extension and this was reduced and stabilized to within 1 mm of anatomic in all cases. In the semi-extended nailing group there were 36 (92%) AO/OTA type A, and 3 (8%) type C. In the standard nailing group there were 39 (81%) type A, and 9 (19%) type C. The average angulation at union in the semi-extended group was 3.1° ± 1.7° (range, 0-5°) versus 3.6° ± 2.1° (range, 0-9°) in the standard group (P = 0.25). No patients (0%) in the semi-extended group had malaligned fractures, compared to 10/48 21% patients in the standard group (P = 0.002).

Conclusion: The semi-extended nailing technique, and its variations, is becoming a more popular way to nail tibia fractures. The technique can be used for both proximal and distal tibia fractures. Our percentage of malaligned patients in the standard group is similar to previous studies. We had significantly more patients with malalignment in the standard group compared to the semi-extended group.

How Scary Is This? Characterizing Antibiotic Use for Type III Tibia Fractures

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Purpose: Infection remains the most common and significant complication following high-energy fractures, and is a particular concern for open tibia fractures. The use of antibiotics is a key component of the treatment of these injuries and the prevention of subsequent infection. However, little is known about variation in the use of antibiotics or the confounding use of antibiotics by other treating teams for other trauma-related conditions. The goal of this analysis is to characterize antibiotic use during the index hospitalization for type III tibia fractures.

Methods: Participants (N = 509) with open Gustilo type III tibia fractures or traumatic tibial amputation were recruited across 31 Level I trauma centers and followed for 6 months following definitive soft-tissue closure. Analyses that follow were conducted using data for 433 participants with complete antibiotic use data at the index hospitalization. Trained research coordinators documented antibiotic use during the index hospitalization (defined as the procedure during which the definitive soft-tissue closure occurred). Participants were 74% male, 69% white, 88% polytraumatized, and had a mean age of 39.0 years.

Results: Overall, for the 433 participants, we document 2371 antibiotic courses during the index hospitalization. The mean, standard deviation (SD), median, minimum (Min), and maximum (Max) number of antibiotic courses per participant was 5.5 (SD 4.7, median 4, Min 1, Max 41). Similarly, mean number of classes of antibiotics per participant was 2.6 (SD 1.3, median 2, Min 1, Max 7). The percent of courses using the most common antibiotics are shown on the left-hand side of the table. The percent of courses receiving the most common antibiotic classes are shown on the right-hand side of the table.

Conclusion: These data show that even during a single hospitalization, trauma patients are receiving a wide range of antibiotics and antibiotic classes, with 4 antibiotics and 3 antibiotic classes appearing to be the norm. The consequences of exposure to multiple antibiotics on wound flora and the development of resistant strains are not known. The results emphasize the importance of developing and implementing improved microbial identification approaches that might be able to better inform clinician decision-making around antibiotic use.

Antibiotics:	Percent of Courses:	Antibiotic Classes:	Percent of Courses:
Ancef	42.3	Cephalosporins	46.8
Vancomycin	14.4	Aminoglycosides	15.3
Gentamicin	9.4	Penicillins	5.2
Tobramycin	5.7	Quinolones	3.8
Piperacillin	3.5	Carbapenems	1.4
Clindamycin	3.2	Antifungal	0.3
Other	21.4	All Other IV	22.0
		All Others PO	5.3

See pages 47 - 108 for financial disclosure information.

Metaphyseal Distal Tibia Fractures: A Cohort, Single-Surgeon Study Comparing Outcomes of Patients Treated with Minimally Invasive Plating Versus Intramedullary Nailing

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Purpose: The optimal treatment of metaphyseal distal tibia fractures has been debated in the literature. In recent years, minimally invasive plate osteosynthesis (MIPO) and intramedullary nail (IMN) fixation have been commonly used to treat this injury pattern. Both treatment modalities use biology-preserving (indirect) techniques for fracture reduction but the implants' designs and their application are very different. We hypothesized that there would be no difference in clinical or functional outcomes when using MIPO or IMN to treat distal tibia fractures in a similar population.

Methods: We evaluated all patients with metaphyseal distal fractures (<5 cm from the joint) treated with MIPO or IMN at a busy trauma center by a single fellowship-trained orthopaedic trauma surgeon from 2003 to 2013. Clinical and radiographic evaluation at a minimum of 1-year follow-up was obtained along with limb-specific assessments (Olerud and Molander's ankle score [OMAS], American Orthopaedic Foot & Ankle Society [AOFAS] ankle-hindfoot instrument), and whole-person assessment with the Short Form-36 (SF-36) tool.

Results: We studied 86 patients with distal tibia fractures treated with MIPO (43) and IMN (43). 37 patients in the MIPO group and 27 in the IMN group met inclusion criteria. All patients ultimately healed, with the average time to union of 23 weeks in both groups. Complications were similar between the two groups (MIPO vs IMN, respectively), and included nonunion (8% vs 7%), malalignment (3.6% vs 3%), wound complications (3.6% vs 3%). The need for secondary procedures for removal of implants was 18.5% in the IMN group (distal locking screws only in 4/5) versus 8% in the MIPO group (P = 0.19). Additionally, AOFAS score and SF-36 domains scores were similar between the two groups. OMAS was significantly better in the MIPO group (86.6 vs 78.4, respectively; P <0.02).

Conclusion: Similar clinical results and functional outcomes were obtained when treating non- or minimally articular metaphyseal distal tibia fractures with MIPO or IMN except for one of two ankle scores that favored MIPO.

Outcome After Olecranon Fracture Repair: Does Construct Type Matter?

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Background/Purpose: Both plate and screw fixation and tension band wiring for simple and comminuted displaced olecranon fractures have been advocated. Few studies have explored the impact of these two surgical techniques on patient clinical outcomes and complication rates. This study compares clinical and functional outcomes of patients with displaced olecranon fractures treated with either a tension band wire (TBW) or a plate construct (PC).

Methods: We performed a retrospective review of operatively treated olecranon fractures by two surgeons at an academic medical center over a 7-year period. Patient demographics, injury information, and surgical management were recorded. Fractures were classified according to the OTA and Mayo systems. A single fellowship-trained orthopaedic trauma surgeon utilizing a similar construct in all cases performed all TBWs. Plate constructs were performed by one of two surgeons and consisted of either a precontoured or one-third tubular "hook" plates contoured intraoperatively and applied to the dorsal aspect of the proximal ulna. Measured outcomes included range of elbow motion, time to union, and development of postoperative complications. To assess functional outcomes, the Mayo Elbow Performance Score (MEPS) was obtained for all patients. Outcomes were compared using an unpaired, two-tailed Student t test and the Fisher exact test with significance defined as a P value <0.05. All patients were followed for a minimum of 6 months.

Results: A total of 58 patients were included in this study: 23 fractures were treated with a TBW and 35 fractures with a plate and screw construct. Both groups were similar with respect to patient sex, age, OTA and Mayo fracture type, and duration of follow-up (14 ± 9.5 months in TBW, 13 ± 19.2 months in PC). Patients undergoing plate fixation had more severe postoperative flexion contractures at their final office visit than those undergoing TBW (-9° ± 7.6° vs -4° ± 9.4°, P = 0.02). Time to radiographic union was longer in the plate group (18 ± 8 weeks) versus the TBW (13 ± 8 weeks) as well (P = 0.03). MEPS scores were slightly better in the TBW group versus the PC group (97.6 ± 5.2 vs 93.1 ± 8.6, P = 0.03). There was no difference in rates of symptomatic hardware between groups (26% in TBW vs 33% in PC, P = 0.98). No difference was observed between groups for postoperative range of motion, rate of heterotopic ossification, or rate of reoperation for any reason. Two patients in each group required a second surgery.

Conclusion: This study suggests that TBW and plate fixation of olecranon fractures have similarly excellent functional outcomes in the olecranon fracture subtypes studied. Those patients undergoing plate fixation had longer time to union and slightly worse MEPS scores, although the clinical significance of the difference was minimal. TBW remains an effective treatment for appropriately selected olecranon fractures, and in this cohort outperformed plate osteosynthesis.

See pages 47 - 108 for financial disclosure information.

Regional Anesthesia Only for Clavicle Fracture ORIF Is Safe and Effective

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Purpose: The purposes of the present study were (1) to report on the efficacy of a combined brachial plexus and superficial cervical plexus block in providing anesthesia for clavicle fracture open reduction and internal fixation (ORIF), and (2) to compare important quality measures such as recovery time, admission rate, and pain medication consumption between patients receiving regional versus general anesthesia.

Methods: This study is a retrospective review of patients undergoing ORIF of the clavicle at a single institution over a 20-month period between 2013 and 2014. All patients undergoing clavicle fracture ORIF received either general anesthesia, regional anesthesia (combined block), or general with interscalene block in a nonrandomized manner. The decision for type of anesthesia was made by the patient and attending anesthesiologist. Any complications related to anesthesia were noted, as were the postanesthesia care unit (PACU) phase I recovery time and the time from PACU transfer to discharge. Medications ordered for pain and nausea/vomiting intra- and postoperatively were documented. Analysis of variance (ANOVA) and chi-squared tests were planned to assess differences between groups, with $P < 0.05$ considered statistically significant.

Results: Subjects were divided into 3 groups based on anesthetic technique: regional anesthesia with combined block ("regional," n = 15), general anesthesia with brachial plexus block ("general block," n = 21), and general anesthesia without block ("general only," n = 7). There were no differences between the groups in age, gender distribution, or American Society of Anesthesiologists (ASA) status. All surgical procedures were completed under the planned anesthesia type. Intraoperatively, general only patients received the highest levels of adjunctive medications and regional patients the lowest levels. This was true for fentanyl (ANOVA $P < 0.001$), hydromorphone ($P = 0.02$), morphine ($P = 0.004$), ondansetron ($P = 0.001$), and metoclopramide ($P < 0.001$), but not for acetaminophen ($P = 0.16$). Postoperatively, the amount of pain medication required was lowest for the regional group (2.2 orders regional vs 3.0 general block vs 7.4 general only, ANOVA $P < 0.001$), but the number of nausea and vomiting medications ordered did not differ significantly between the groups. PACU phase I recovery time was longer in patients who received any general anesthesia (125 minutes general only vs 106 general block vs 63 regional, ANOVA $P = 0.04$), as was time from PACU admission to discharge. None of the regional patients were admitted overnight (0%), while 1 general block patient was admitted (4.8%) and 3 general only patients were admitted (42.9%). These rates were significantly different ($P = 0.003$).

Conclusion: Regional only anesthesia for clavicle fracture ORIF was demonstrated to be safe and effective and no cases required conversion to general anesthesia. The combined block also performed better than general anesthesia with or without brachial plexus block in terms of postoperative recovery time, overnight admission rate, and postoperative pain control.

POSTER ABSTRACTS

Incidence of Iatrogenic Radial Nerve Palsy Following Repair of Humeral Shaft Nonunion

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Purpose: The rate of iatrogenic radial nerve palsy following repair of acute humeral shaft fractures is approximately 6.5%. To our knowledge, no study has investigated the rate of occurrence of iatrogenic radial nerve palsy following surgical repair of established humeral shaft nonunion (HSNU). We hypothesize that the incidence of radial nerve palsy is higher following repair of an established HSNU when compared to historical rates reported for open reduction and internal fixation (ORIF) of acute humeral shaft fractures.

Methods: This study was conducted at an academic Level I trauma center following IRB approval. All patients who underwent operative treatment of an HSNU were identified from a fracture treatment database. Inclusion criteria were an HSNU confirmed both clinically and radiographically, absence of a preoperative radial nerve palsy, and postoperative clinical follow-up documenting radial nerve function. 63 surgically managed HSNUs were identified, of which 54 patients (86%) had adequate postoperative neurologic examination for inclusion in the study. The main outcome was diagnosis of postoperative iatrogenic radial nerve palsy.

Results: 54 patients were included in the cohort. Median age was 54.5 years (range, 21-93 years) with 24 males and 30 females. Ten patients (18.5%) developed iatrogenic radial nerve palsies: eight experienced complete resolution (mean, 2.5 months) and two experienced partial resolution. There were no statistically significant differences between patients who developed nerve palsy and those who did not in regards to age, gender, tobacco use, diabetic status, initial management (operative vs nonoperative), surgical approach, presence of infected nonunion, number of previous surgeries, or operative time (P >0.05).

Conclusion: The incidence of iatrogenic radial nerve palsy for patients undergoing surgical repair of an HSNU was 18.5%. According to historical data, this rate is nearly three times higher than for those undergoing ORIF of acute humeral shaft fractures.

See pages 47 - 108 for financial disclosure information.

Radial Head Replacements for Elbow Trauma: Functional Outcomes and Complications

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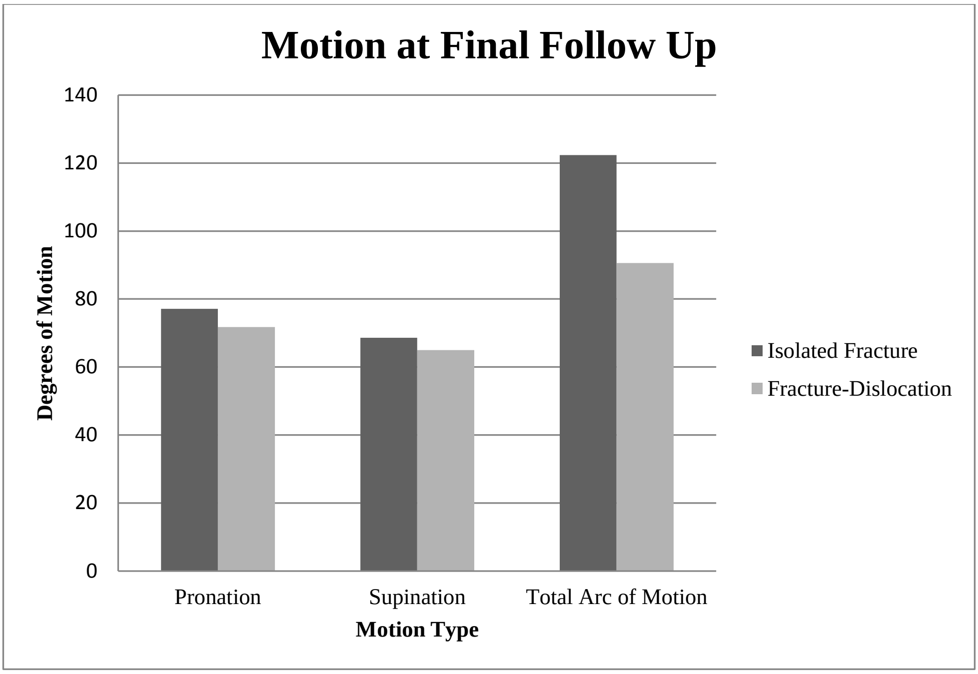
Purpose: Radial head replacement is a common treatment for complex radial head and neck fractures, but there is a dearth of information about clinical outcomes. Our purpose was to review our experience with radial head arthroplasty for the treatment of complex elbow injuries.

Methods: 72 patients were identified in the trauma database of a large urban academic medical center. Data collected included: age, injury pattern, and operation type. Follow-up data included clinical elbow range of motion (ROM), pronation, and supination at 3 months, 6 months, and 12 months postoperative, and ROM at final follow-up. The following complications were recorded: development of heterotopic ossification and contracture, infection, posttraumatic arthritic changes, and reoperations for hardware removal or revision and contracture release. Subjects were grouped by severity of injury: those with isolated radial head fractures and those with associated fracture-dislocations. Data were analyzed using an independent t test.

Results: The average age of patients was 52.5 years. Mean length of follow-up was 12 months (range, 6-54 months). 26% had isolated radial head fractures and 74% had fractures with an associated elbow dislocation. At final follow-up, patients with a fracture-dislocation experienced an insignificant reduction in arc of elbow ROM compared to those with isolated fractures ($P = 0.865$). However, supination diminution was statistically significant between the fracture dislocation group ($67.13° \pm 17.791°$) and the isolated fracture group ($76.00° \pm 7.368$) at final follow-up ($P = 0.012$) with a mean difference of 8.875°. Heterotopic ossification was the most common adverse finding, occurring in 23% of cases, 25% of isolated fractures and 23% of fracture dislocations. 5% of patients underwent removal of their radial head prosthetic due to infection or heterotopic bone formation. 83% of patients regained functional range of motion (30°-130°). There were no other significant differences in complication rate, need for contracture release surgery, incidence of removal of hardware, or posttraumatic arthritic change on the capitellar side.

Conclusion: Radial head arthroplasty is a reliable procedure in both simple and complex radial head trauma with good clinical results. When treated with arthroplasty, radial head injuries function well and lead to good results. When performed for a radial head fracture in association with elbow dislocation, patients experience decreased supination motion. However, there is no difference in arc of elbow flexion, nor are there significant differences in complication rates.



POSTER ABSTRACTS

See pages 47 - 108 for financial disclosure information.

Narcotic Requirement Is Not a Predictor of Adult Upper Extremity Compartment Syndrome in the Trauma Patient

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Background/Purpose: The diagnosis of compartment syndrome is often difficult to establish, especially in the non-verbal or obtunded patient. In the pediatric trauma population, increased narcotic requirement has been thought to be a predictor of upper extremity compartment syndrome. We sought to assess the presence of classic physical examination findings, pain medication requirements prior to fasciotomy, and changes in vital signs to determine predictors of compartment syndrome following upper extremity trauma in the adult population. We sought to asses if narcotic requirement is a predictor of adult upper extremity compartment syndrome in the trauma patient and hypothesized that it is not.

Methods: Patients admitted to a Level I trauma center between 2007 and 2012 who were diagnosed with compartment syndrome in the upper extremity and underwent fasciotomy were retrospectively reviewed. A control group of trauma patients matched for age, extremity affected, and mechanism of injury was obtained. Objective data including heart rate, systolic blood pressure (SBP), pain score (based on visual analog scale), narcotic requirement prior to surgery, time from injury to fasciotomy (cases), or open reduction and internal fixation (controls) were obtained from the medical record. In addition, the presence of the "6 Ps" (pain, paresthesia, pallor, paralysis, pulselessness, and poikilothermia) were recorded for cases and controls. Differences in these parameters were compared between the groups.

Results: "Pain with passive stretch" was present in 50% of the cases versus 0% in the controls ($P < 0.05$). A significant difference in the average heart rate was also present between the cases and controls (103 vs 87) ($P < 0.05$). There was no statistically significant difference in the average pain score in the last 4 hours prior to operative intervention or during the entire period prior to surgery in cases versus controls (6.9 vs 8.2 and 7.2 vs 8.3, respectively; $P = 0.281$, 0.384). There was also no significant difference in the percentage of cases who exhibited any one of the "6 Ps" as compared to the controls. The average SBP was not different between cases and controls (140 vs 133, $P = 0.411$). The average narcotic requirement in the cases versus controls overall or in last 4 hours prior to surgery was not significantly different.

Conclusion: Average heart rate and pain with "passive stretch" were significant predictors of compartment syndrome. However, the "6 Ps", SBP, narcotic requirements, and patient-reported pain scores were not. In an adult upper extremity trauma population, the pulse rate may be a useful indicator of developing compartment syndrome and should be closely monitored in the at-risk patient.

Immediate Sarmiento Bracing for the Treatment of Humeral Shaft Fractures

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Background/Purpose: We sought to compare the radiographic alignment of humeral shaft fractures treated with immediate Sarmiento bracing versus coaptation splinting. Coaptation splints require skillful application, are difficult to maintain, and are prone to skin complications. Our study evaluates if immediate application of a Sarmiento fracture brace produces equivalent radiographic alignment when compared with coaptation splinting.

Methods: This is a retrospective study of 38 patients treated for humeral shaft fractures between 2003 and 2008. 14 patients were initially treated with immediate Sarmiento bracing and 24 were initially treated with coaptation splinting. The alignment in the coronal and sagittal planes were measured on the pre- and postimmobilization radiographs. The same measurements were taken at the initial clinic visit and followed until fracture union. Demographic data were also collected.

Results: Of the 14 patients treated with immediate Sarmiento bracing, the average varus alignment after brace application was 9.38° compared to 10.96° in those treated with immediate coaptation splinting. The number of patients with acceptable alignment after reduction was 10 of 12 patients who had complete postreduction radiographs for the immediate Sarmiento group and 19 of 23 for the immediate coaptation group. The average change in varus alignment after initial reduction was 15.69° for the immediate Sarmiento group and 16.25° for the coaptation group. Four patients treated with coaptation splinting underwent a repeat reduction in the emergency department, whereas 0 patients in the Sarmiento group required repeat reduction. Patients in both groups were similar with regards to initial injury displacement, radial nerve palsy, conversion to operative fixation, loss to follow-up, and nonunion. In the Sarmiento group, 3 of 14 patients (21%) eventually failed conservative treatment and converted to ORIF (open reduction and internal fixation) compared to 7 of 24 patients (29%) in the coaptation group.

Conclusion: Postreduction alignment was similar following immediate application of the Sarmiento brace as compared with coaptation splinting. Equivalent proportions of patients had acceptable postreduction alignment and less likely to require a rereduction attempt. Given the difficult nature of coaptation splinting, these findings support immediate Sarmiento application as a more comfortable and effective initial treatment for those patients with a humeral shaft fracture.

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Scoring of Cortical Healing Predicts Union in Humeral Shaft Fractures

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Purpose: Humeral shaft fractures treated nonoperatively have a nonunion rate of 10%. Identifying patients with humeral shaft fractures that are going on to nonunion is important for patient counseling and delivery of effective care. The purpose of this study is to determine if a modified radiographic union score for tibial fractures (RUST) system is predictive of union in humeral shaft fractures treated nonoperatively.

Methods: All patients with long bone fracture nonunion presenting to a single surgeon were enrolled in a prospective registry. Enrolled patients were followed at regular intervals using the Short Musculoskeletal Function Assessment (SMFA), physical examination, and radiographic examination. This registry was queried to identify patients with humeral shaft fractures that were treated nonoperatively and went on to nonunion. The nonunion patients were matched to a three to one gender- and age-matched control group that achieved union. Two fellowship-trained traumatologists blinded to eventual union status scored radiographs obtained 12 weeks after injury using the radiographic humerus union measurement (RHUM) scoring system, which was previously validated at our institution in humeral shaft fractures treated nonoperatively. Differences in RHUM score were averaged. A binomial logistic regression was performed to determine the effect of RHUM score applied to humeral shaft fractures on the likelihood of developing union.

Results: Nine patients with humeral shaft fractures that were treated nonoperatively and went on to nonunion were identified. These patients were matched to 27 gender- and age-matched controls who achieved union. Logistic regression showed that the RHUM score applied to humeral shaft fractures was a significant predictor of healing (P = 0.014, odds ratio [OR] 9.434, 95% confidence interval [CI] for OR 1.586 to 56.098) after humeral shaft fracture treated nonoperatively. All patients with RHUM score below 7 went on to develop nonunion. All patients with RHUM score above 8 went on to union without further intervention. Three of 7 patients (43%) with RHUM score of 7 or 8 went on to union without further intervention.

Table 1:

RHUM Score	4	5	6	7	8	9	10	11	12
Union	0	0	0	1	2	7	9	5	3
Nonunion	1	0	4	1	3	0	0	0	0
Percent Union	0	0	0	50	40	100	100	100	100

Conclusion: The RHUM score applied to humeral shaft fractures showed an increased likelihood of achieving union with increasing RHUM 12 weeks after injury. Orthopaedic surgeons can counsel patients with fractures with RHUM scores of 6 or below that they are in danger of developing nonunion, scores of 9 or above should achieve union, and scores of 7 or 8 achieve union less than half of the time. This allows surgeons to target interventions appropriately.

Complications of Locked Intramedullary Nail Treatment of Proximal Humerus Fractures

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Background/Purpose: Proximal humeral intramedullary nailing allows a less invasive surgical intervention than locked plating, maintaining the vascularity of fracture fragments while potentially providing angular stability of proximal fixation. Some studies have demonstrated that this technique shows comparable or improved clinical outcomes and complications to locked plating, with others showing less favorable outcomes and a higher complication rate, particularly in complex fractures. The purpose of this study is to assess the early outcomes and complications of 2-, 3-, and 4-part fractures of the proximal humerus using a locked intramedullary nail for open reduction and internal fixation of fractures of the proximal humerus. The nail utilized in this study provides angular-stable targeted proximal screw orientation for compressive fixation of the tuberosities.

Methods: From April 2009 to April 2013, 110 consecutive proximal humeral fractures with displaced Neer 2-, 3-, or 4-part proximal humerus fractures were acutely treated with the short antegrade intramedullary locked nail at three institutions. Inclusion criteria were a fracture confined to the proximal humerus without associated humeral shaft extension and a minimum of 12-month clinical and radiographic follow-up. Outcomes were evaluated using the Constant score, radiographic evaluation, and assessment of complications or additional surgical intervention.

Results: 32 patients (29%) were lost to follow-up, or had not been seen for a minimum of 1-year follow-up. Of the 78 patients with at least 1-year follow-up (mean 17 months, range 12-51 months), 35 were 2-part, 26 were 3-part, and 17 were 4-part fractures. 48 were female and 30 were male, with a mean age of 58 years (range, 16-86). Complications included 4 cases of avascular necrosis, two of which occurred in 4-part fractures, one with a 3-part fracture, and one after revision of a 2-part fracture that had failed another form of fixation. One patient, with a 2-part fracture, complained of shoulder stiffness that was treated with arthroscopic adhesiolysis. Three patients with 3-part fractures had one or more screws removed after healing. One patient, with a 3-part fracture, exhibited signs of rotator cuff failure postoperatively and underwent nail removal with rotator cuff repair. One patient with a 4-part fracture underwent revision intramedullary nailing for fracture displacement after the index surgery. For the entire cohort, final follow-up average active forward flexion was 128° (range, 60°-170°), active abduction 137° (range, 60°-170°), and active external rotation 46° (range, 0-90°). Constant scores were available for 76 fractures. The average final age-adjusted Constant score was 86.9 (range, 13-121), with an average pain score of 13.3 (range, 5-15).

Conclusion: Operative treatment of displaced proximal humerus fractures using this technique resulted in favorable healing rates and clinical outcomes. At average 17-month follow-up the avascular necrosis rate was 5%. Nine patients (12%) required additional surgery

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during the follow-up period and three patients (4%) required conversion to an arthroplasty. The majority of complications occurred in more complex fracture patterns.

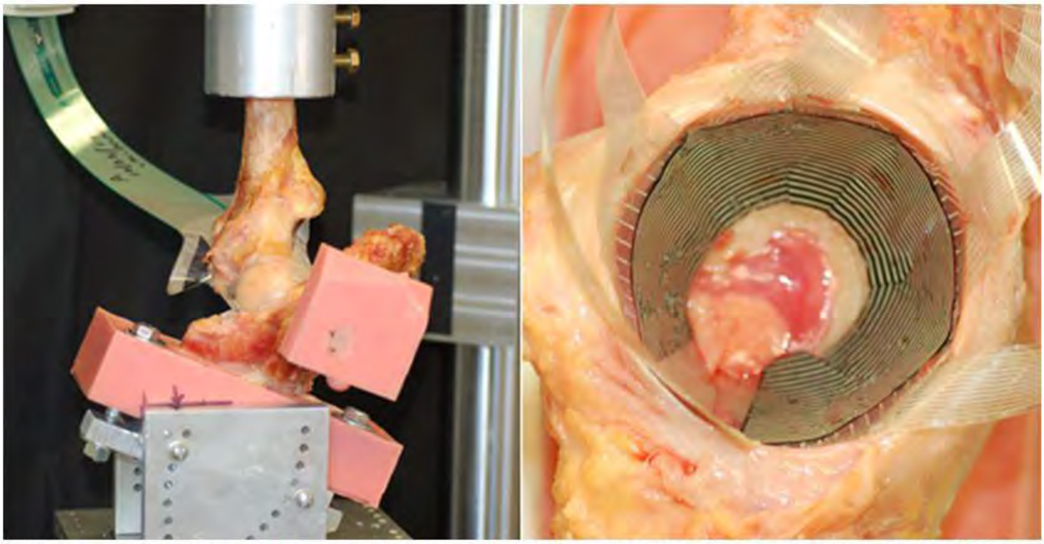

Figure 1. Experimental setup using a custom fixture to apply a 1,000N compressive force across the hip joint (Left). The pelvis was rigidly attached to a plate that was free to translate in the X-Y directions. The femoral shaft was rigidly attached to the material testing machine loaded in the z-direction. Coverage of the acetabular cartilage by the Tekscan sensor is shown on the right.

Figure 2. The posterior wall fracture and 2-mm step-off malreduction created in Specimen 1.

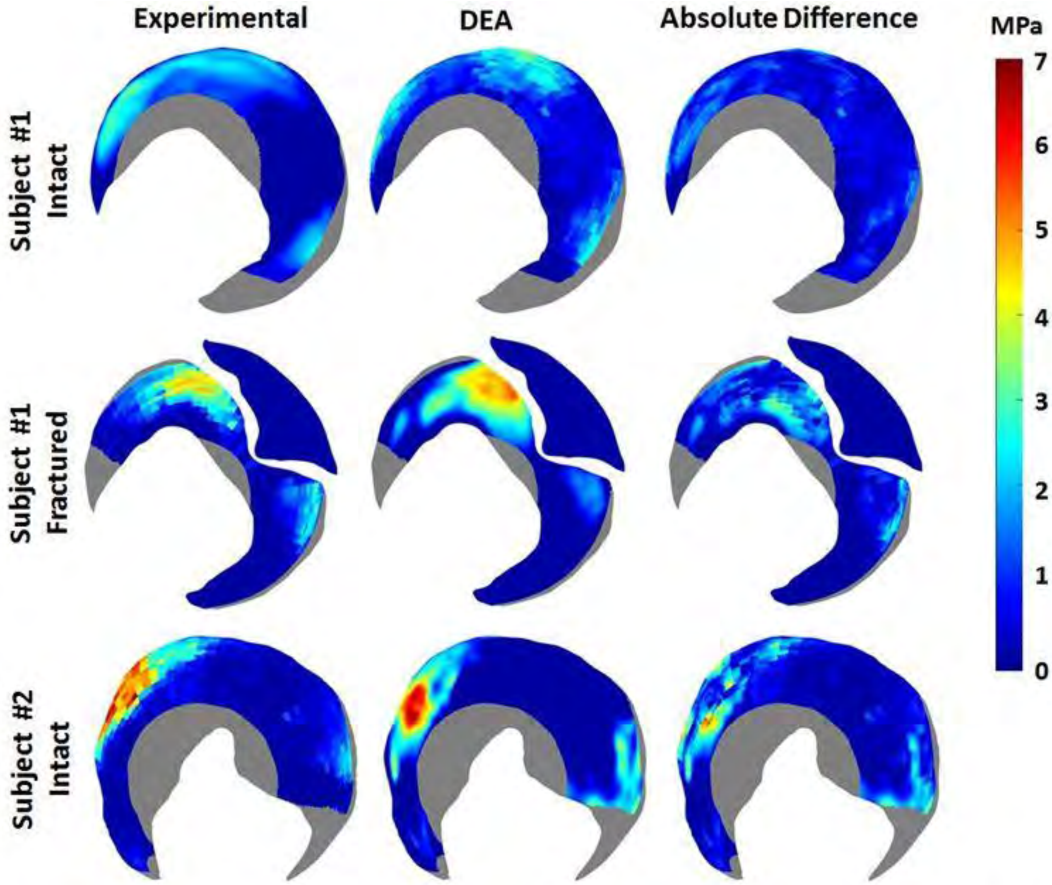

Figure 3. Plots of experimental contact stresses, DEA-computed contact stresses, and a point-by-point absolute difference map(|DEA – Experimental|) for subject #1 intact hip (top row), subject #1 malreduced fractured hip (middle row) and subject #2 intact hip (bottom row). Areas of acetabular cartilage not covered by the Tekscan sensor during testing are colored grey and were not included in contact stress comparisons.

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WITHDRAWN

Small-Fragment Plate Fixation of Humeral Shaft Fractures

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Purpose: Humeral shaft fractures (HSFs) have traditionally been treated surgically with large-fragment (4.5-mm) plates. Orthopaedic traumatologists at our institution often prefer treatment with small-fragment (3.5-mm) plates. Our hypothesis was that fractures treated with a 3.5-mm plate would have an unacceptable complication rate in comparison to patients treated with 4.5-mm plates, particularly in the group allowed full weight bearing on the humerus.

Methods: A retrospective chart and radiographic review was performed of all humeral shaft fractures (OTA 1.12A-C, open and closed) treated with open reduction and internal fixation at a Level I urban trauma center from January 2003 to June 2014. We excluded patients with proximal and distal periarticular extension as demonstrated by use of anatomically contoured proximal or distal plates (n = 169). We also excluded patients who had inadequate follow-up to determine healing (n = 93). Patients were typically managed with immediate weight bearing as tolerated without bracing except in cases such as ipsilateral upper extremity fracture preventing weight bearing, or radial nerve palsy, and in these cases immediate activities of daily living were allowed but weight bearing was limited. Plate thickness (4.5 mm vs 3.5 mm) was based upon surgeon preference. Our primary outcome measure was nonunion and our secondary outcome measure was plate breakage. Our study group consisted of 191 (3.5 mm: n = 150, 4.5 mm: n = 41) fractures that were further subdivided into four groups: (1) 3.5-mm plate with immediate weight bearing (n = 96, 64% of 3.5-mm cohort), (2) 3.5-mm plate without immediate weight bearing (n = 41), (3) 4.5-mm plate with immediate weight bearing (n = 29, 70% of 4.5-mm cohort), and (4) 4.5-mm plate without immediate weight bearing (n = 9). Two-sided Fisher exact was used for the analysis.

Results: Consistent with prior studies, we had a low overall nonunion rate in our study group (n = 191, nonunion = 8.3%, 95% confidence interval [CI]: 4.4%-12.3%). The nonunion rate was similar in the 3.5-mm and the 4.5-mm group overall (8.7% nonunion vs 7.3%, P = 1.00) as well as within the subgroups that did and did not have immediate weight bearing (3.5 mm: 9.38% nonunion vs 4.5 mm: 3.45%, P = 0.46 and 3.5 mm: 9.76% nonunion vs 4.5 mm: 22.2%, P = 0.59). Our secondary outcome measure of plate breakage was also similar between the 3.5-mm and 4.5-mm groups (3.3% vs 2.4%, P = 1.00).

Conclusion: Our data contradict our hypothesis and demonstrate that humeral shaft fractures treated with 3.5-mm plates appear to have a comparable nonunion and hardware failure rate to historical controls treated with 4.5-mm plates as well as our own internal control group. This study is limited by lack of randomization and potential selection bias as 27% of the patients were treated with 4.5-mm plates perhaps indicating that not all humeral shaft fractures were thought to be appropriate for 3.5-mm size fixation. With this caveat in mind, our data support the use of 3.5-mm plate fixation for select fractures as a reasonable alternative, even for cases of immediate weight bearing on the humerus.

See pages 47 - 108 for financial disclosure information.

Predictors of Persistent Pain After Distal Clavicle Fracture Fixation in an Active Military Population

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Purpose: Previous studies reporting on distal clavicle fractures have demonstrated a high rate of hardware removal and persistence of symptoms, particularly in those attempting to return to high-demand activities. The purpose of this study is to evaluate the clinical and occupational outcomes of military service members following surgical management of distal clavicle fractures.

Methods: All active-duty service members undergoing primary distal one-third clavicle fracture open reduction and internal fixation (ORIF) between October 17, 2007 and July 20, 2012 were reviewed. Inclusion criteria were applied to all active-duty service members with confirmed group II clavicle fractures and minimum 2-year follow-up. The electronic health record was queried for each service member to confirm accurate coding and extract pertinent demographic parameters and clinical outcomes to include primary outcomes of persistence of pain, hardware removal, and postinjury deployment.

Results: 48 service members were identified with an average follow-up of 3.8 years (range, 2.0-6.7). The average age was 30.3 years (range, 20.0-50.8). 35% (n = 17) experienced persistence of symptoms, 44%(21) required hardware removal, and 35% (n = 17) returned to deployment. 100% of fractures reached radiographic union, although 4% (n = 2) were delayed unions. There was a higher rate of symptom persistence in those treated with hook plates (58%, n = 7) compared to those treated with standard plating technique (28%, n = 10), even after hardware removal (odds ratio [OR] 3.64, confidence interval [CI] 0.93-14.18, P = 0.063). There was an increased rate of symptom persistence in those who underwent hardware removal (48%) than those without (26%), and this approached significance (P = 0.12). The incidence of persistence of pain in those who underwent concomitant coracoclavicular fixation (33%) was not significantly different than those without coracoclavicular fixation (36%) (P = 0.88). As body mass index (BMI) increases, there is a trend towards nondeployment in those who undergo distal clavicle fracture ORIF (OR 0.77, CI 0.59-1.01, P = 0.0598). There was no significant difference in the rate of those who deployed with or without hardware removal (48% and 26%, respectively; P = 0.12). There was also no significant difference in the rate of those who deployed with or without persistence of symptoms (P = 0.52).

Conclusion: At a mean 4-year follow-up, there was a 3.6-fold increase in persistence of symptoms in those treated with a hook plate despite routine plate removal. Overall persistence of pain occurred in 35% of patients, with increases to 59% among those treated with hook plates. There is an increased overall rate of persistence of symptoms in patients who have undergone hardware removal. Among patients with high upper extremity occupational demands, such as active-duty military service members, there is a high incidence of persistent symptoms and hardware removal. Persistence of pain and hardware removal did not prove to be a significant risk factor in preventing deployment.

Elbow Release in Patients Following Elbow Contracture: An Effective Modality

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Purpose: Posttraumatic elbow contracture is a complication that follows complex elbow trauma, and results in limited range of motion. The purpose of this study is to characterize the affected patient population, operative management, and outcomes following elbow contracture release.

Methods: A retrospective chart review was conducted to identify all patients who underwent posttraumatic elbow contracture release performed by two orthopaedic surgeons at our institution between the years of 2004 and 2014. Medical records were reviewed to characterize patient demographics, injuries, operative details, outcomes, and complications. All patients underwent surgical treatment for their contracture that included the following elements: removal of hardware (45%), excision of heterotopic ossification (86%), and capsular release (98%). A paired-samples t test was used to determine if there was a significant mean difference in elbow arc of motion before and after elbow contracture release surgery.

Results: 54 patients underwent posttraumatic elbow contracture release at our institution in the identified time period. 49 patients had a minimum of 6 months follow-up and were included in our study. Mean age of patients at time of contracture release was 44.8 years (standard deviation [SD] 14.3). The cohort consisted of 23 men (47%) and 26 women (53%). The most common mechanism of initial elbow injury was low-velocity fall (61%). 40 patients (82%) were initially treated operatively for their initial injuries. Mean elbow arc of motion prior to contracture release was 61.7° (SD 33.0). Mean arc of motion after contracture release was 100.0° (SD 28.0). Paired samples t test showed elbow contracture release resulted in a significant increase of 38° in elbow arc of motion ($P < 0.0005$, 95% confidence interval [CI] 30.3 to 45.8). Five patients (10%) had a subsequent complication. One patient developed a posterior interosseous nerve palsy that resolved. One patient developed an ulnar nerve palsy that resolved. Two patients developed post-perative infection. One patient required treatment for post-perative seroma. Seven patients (14%) had radiographic recurrence of heterotopic ossification after contracture release. Six patients (12%) required a secondary reoperation to gain more motion.

Conclusion: Patients with posttraumatic elbow contracture can make significant gains in arc of motion after contracture release surgery. Patients can expect to recover a functional elbow arc of motion. However, patients must be counseled that a high percentage of patients will have recurrence of heterotopic ossification and may require more than one procedure to achieve motion.

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Predictors of Nonunion After Operative and Nonoperative Management of Humeral Shaft Fractures in a Level I Trauma Center

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Purpose: Humeral shaft fractures occur commonly, often caused by high-energy trauma in young males and low-energy falls in elderly females. Historically, most were treated nonoperatively with a more recent trend toward more operative treatment, even for isolated injuries. Our aim is to identify predictors of nonunion after operative and nonoperative management of humeral shaft fractures.

Methods: Records of 603 adult patients with humeral shaft fracture were reviewed, and 326 patients with adequate clinical and radiographic records were included. Multivariate logistic regression analysis was used to identify significant predictors of outcome.

Results: Mean age was 44.1 ± 18.7 years, with female/male ratio 0.71, and mean body mass index (BMI) 29.1 ± 6.9. Comorbidities were present in 154 (47.4%) patients; a large proportion were smokers (41.1%) and used alcohol (42.9%). Motor vehicle collision was the most common mechanism of injury (28.1%), followed by fall from standing (26.5%), fall from height (13.2%), motorcycle collision (8.8%), and gunshot wound (8.2%). Shaft fractures most often occurred in the middle third (43.8%), with 30.8% in distal and 25.4% in proximal thirds. 72 (22.3%) were open fractures. Nerve palsy was present in 91 patients (27.9%) with radial nerve the most commonly injured nerve (76.9%). Overall, 138 patients (42.3%) were initially treated nonoperatively, and 188 (57.7%) underwent acute (<10 days) open reduction and internal fixation (ORIF). Surgical patients were younger (41.3 vs 46.9 years, P = 0.006), had fewer comorbidities (40.4% vs 56.5%, P = 0.004), and had similar gender, BMI, and substance use profile. Nonunion developed in 25 (18.1%) patients after nonoperative management and 19 (10.1%) after primary ORIF, while malunion was observed in 7 (5.1%) patients with nonoperative treatment and one (0.5%) operative case (P = 0.04). Simple fracture patterns had the highest risk of nonunion (transverse [A3] 30.0%) versus 17.6% for wedge (B) and 8.8% for complex (C) fractures (P = 0.07). Patients with malunion and nonunion had mean angulation of 29.0° (±8.2°) and 20.5° (±15.6°), respectively, compared to 14.1° (±11.6°) for healed fractures (P = 0.01). Chronic liver disease increased risk of nonunion in both groups (5.1% vs 0%, for operative, P <0.003; and 24.0% vs 3.5% for nonoperative, P = 0.001). In surgical patients cardiovascular disease, smoking, and alcohol use were associated with 2 to 3-fold increase in nonunion rate. Nerve recovery was observed in 79%, regardless of treatment, with mean time to recorded complete recovery 75.0 days. 29 patients (15.4%) had complications after ORIF, including iatrogenic nerve palsy (8.0%), infection (4.8%), and hardware failure/prominence (4.7%), and three patients (2.2%) had to undergo revision plate fixation.

Conclusion: Over half of our patients underwent ORIF. The surgical population had younger mean age and fewer comorbidities, and more commonly had high-energy injuries. Nonunion and malunion were more frequent with nonoperative treatment; especially transverse fracture patterns. Isolated comminuted fractures often achieve union after nonoperative care, while certain simple patterns at high risk may benefit from early ORIF. Comorbidities, especially chronic liver disease, tobacco, and alcohol use were associated with high rates of nonunion, even after ORIF. Complication rates with surgery are concerning, and modifiable patient risks should be addressed.

Is a Postoperative Chest Radiograph Necessary After Open Reduction and Internal Fixation of a Clavicle Fracture in a Trauma Population?

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Purpose: Controversy remains over the usefulness of a postoperative chest radiograph (CXR) after open reduction and internal fixation (ORIF) of the clavicle when associated with concomitant thoracic injury. This study was performed to determine if certain subsets of patients are at increased risk for postoperative pathology on CXR after ORIF of the clavicle.

Methods: A consecutive series of patients at our Level I trauma center were retrospectively reviewed after ORIF of the clavicle. All patients included were treated surgically with superior plating technique and had a postoperative CXR. Each postoperative CXR was evaluated for new or worsened pulmonary contusion, pneumothorax (PTX), and pleural effusion. Risk factors were evaluated as predictors of a pathologic postoperative CXR and included preoperative pulmonary injury, preoperatively placed chest tube, and concomitant rib fractures.

Results: 76 patients were included in the series, including 57 men and 19 women, with an average age of 41.6 years. All patients had postoperative CXRs performed. All were treated with ORIF with superior clavicle plating. According to the OTA classification there were two 15A, forty 15B1, twenty-five 15B2, four 15B3, and five 15C clavicle fractures. 13 patients had a preoperative PTX on CXR and 13 patients had a preoperative PTX on chest CT only. There were 45 patients with rib fractures, 11 patients with chest tubes placed before orthopaedic intervention, and 30 orthopaedic polytrauma patients. Postoperative CXR diagnosed 0/23 (0%) PTX in patients with neither preoperative pulmonary injury nor rib fractures. The postoperative CXR showed presence of a PTX in 1/31 (3.2%) of patients without concomitant rib fractures and in 6/45 (13.3%) of patients with rib fractures. Postoperative CXR showed increased sized of PTX postoperatively in 2/13 (15.4%) patients with PTX visible on preoperative chest CT only and not treated with preoperative chest tube; both patients required postoperative chest tube placement. Seven of 76 patients had PTX visible on postoperative CXR; 2 were new PTX, 3 were stable, and 2 increased in size but did not require intervention. Two of 76 (2.6%) had postoperative pleural effusions seen on CXR, which were treated with chest tube placement in 1/2 (50%) of these patients. The patients with chest tube placement preoperatively had visible PTX on postoperative CXR in 4/11 (36.4%) patients, but the PTX increased in size in only 1/11 (9.1%).

Conclusion: No postoperative CXR is recommended after ORIF of isolated clavicle fractures. However, clavicle fracture patients with concomitant preoperative chest trauma should have postoperative chest radiographs due to the risk of pulmonary complications. These risks are most likely due traumatic injury to the lungs and chest wall, and must be considered in a trauma population.

Does Indomethacin Cause Nonunion When Used for HO Prophylaxis After ORIF of Distal Humerus Fractures?

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Background/Purpose: Open reduction and internal fixation (ORIF) is the standard of care for displaced distal humerus fractures in adults. One of the common problems associated with distal humerus fractures is heterotopic ossification (HO), and it is reported to occur up to 49%. HO is commonly associated with decreased range of motion (ROM). Indomethacin can be used after surgical treatment of distal humerus fractures but it may complicate the fracture healing; as a nonsteroidal anti-inflammatory medication, it may cause nonunion of the fracture. The effect of indomethacin on fracture union in distal humerus fractures has not been reported previously. The purpose of the study was report the radiographic and clinical outcomes of patients with distal humerus fractures treated with ORIF and indomethacin postoperatively.

Methods: All adult patients (>18 years old) treated for distal humerus fracture with ORIF with a minimum follow-up of 6 months were included in the study. All patients were placed on indomethacin 75 mg PO once a day postoperatively for 6 weeks. The arm was placed in a sling for comfort postoperatively. Full active and active-assisted ROM was started on post-operative day 1. Weight bearing was started after fracture union. All patients were followed at 2 weeks, 6 weeks, 12 weeks, 6 months, 1 year, and annually afterwards. A retrospective review was performed and the following data were collected: age, gender, history of HO, associated injuries, fracture type per OTA classification, type of surgical exposure, union at 3 and 6 months, time to union, HO, loss of reduction, failure of fixation, wound-healing problem, infection, and ROM of elbow and forearm.

Results: 29 patients (mean age 46 years; range, 24-67) were included in the study. The majority of fractures were intra-articular (OTA classification: 2 patients Type 13 A, 5 patients 13B, and 22 patients Type 13 C). Mean follow-up was 19 months (range, 12-51 months). Posterior paratricipital approach with olecranon osteotomy was utilized in 14 patients, posterior paracipital approach (without osteotomy) in 12 patients, and lateral approach in 3 patients. There was no nonunion of distal humerus or osteotomy site. Type I HO occurred in 3 patients, and Type II HO in 2 patients. Osteotomy fixation failed in one patient in 2 weeks requiring revision. There was no infection or wound-healing problem. The mean elbow extension was 8°; mean elbow flexion was 142°. Mean forearm supination was 72° and mean forearm pronation 77°.

Conclusion: Nonunion has not occurred when indomethacin was used for prophylaxis against HO after ORIF of distal humerus fractures. Good to excellent ROM of elbow and forearm has also achieved using a standard aggressive protocol.

See pages 47 - 108 for financial disclosure information.

Nerve Injury and Recovery After Traumatic Humeral Shaft Fractures in a Level I Trauma Center

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Background/Purpose: Nerve palsy is detected in up to 22% of humeral shaft fractures, and the radial nerve is the most commonly injured. Classically, distal third humeral shaft fracture (Holstein-Lewis fracture) has been associated with radial nerve palsy, but recent studies report nerve injury with transverse or spiral fracture of the middle to distal third humerus. Isolated nerve injuries after humeral fracture usually recover spontaneously, and operative intervention is rarely indicated. Our goal in this study was to review traumatic nerve injuries associated with humeral shaft fractures and their recovery and response to operative and nonoperative management.

Methods: Records of 603 adult patients with humeral shaft fracture over 15 years (1999-2014) were reviewed, and 326 patients with adequate follow-up and complete nerve function documentation were included in the study. Fracture pattern was classified using AO/OTA classification.

Results: Nerve palsy was present in 91 (27.9%) patients at the time of injury. The radial nerve was the most commonly injured nerve (76.9%), followed by ulnar nerve (5.5%) and axillary nerve (3.3%); 13 patients (14.3%) had multiple nerves palsies. Nerve injury was significantly more common in middle and distal third fractures (45.5% and 41.8%, respectively) compared to proximal third (12.7%, P = 0.02). High-energy trauma was associated with nerve palsy (32.1% vs 22.3%, P = 0.045) versus low-energy injury. There was lower risk of nerve injury with isolated humeral shaft fracture (22.3% vs 33.1%, P = 0.04). Patients who had concurrent vascular injury had the greatest frequency of nerve injury (88.9% vs 26.5%, P = 0.001). There were three bilateral fractures that all had associated nerve injuries. Patients with open fracture had a significantly higher rate of nerve palsy (45.8% vs 22.8%, P = 0.001). Nerve palsy was present in 47.3% of patients with simple (Type A), 30.9% of complex (Type C), and 21.8% of wedge (Type B) fractures (P = 0.83). Complex comminuted (C3) (20.0%), simple spiral (A1) (16.4%) and oblique (A2) (16.4%) comprised more than half of the fractures associated with a nerve injury. Expectedly, patients treated surgically for their humerus fracture had a higher prevalence of nerve injury (38.3%) compared to nonoperative patients (13.8%, P = 0.001). Nerve recovery was detected in 71 (78.0%) patients with 42.3% partial and 58.7% complete recovery. Operative treatment of the fracture had no effect on the outcome of nerve recovery (79.2% vs 73.7%, P = 0.61). Presence of concurrent vascular injury predicted worse frequency of nerve recovery (81.9% vs 37.5%, P = 0.004).

Conclusion: The prevalence of nerve injury associated with humeral shaft fracture was higher than previously reported in the literature. The radial nerve was the most commonly injured nerve. High-energy trauma, fracture in the middle or distal third of the humerus shaft, bilateral fractures, and concurrent vascular injury are associated with greater risk of nerve injury. Operative treatment of humeral shaft fracture does not affect recovery of nerve injury.

Continual Near-Infrared Spectroscopy Monitoring in Acute Compartment Syndrome: Lessons Learned From a Decade of War

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Background/Purpose: Acute compartment syndrome (ACS) is a prevalent and morbid complication of severe extremity injury in the combat and civilian setting. The leg is most commonly involved (>50%). Early experience from the wars in Iraq and Afghanistan demonstrated a 17% rate of delayed or missed diagnosis of ACS in-theater. This resulted in a doubling of major amputation rate and quadrupling of mortality when compared to patients who underwent timely and complete fasciotomy in-theater. The purpose of this work was to summarize the experience with and lessons learned regarding the ideal management of ACS in the combat setting over the last decade of war, and to specifically recount the work to date evaluating the potential of near-infrared spectroscopy (NIRS) to serve as a technological solution for known deficiencies with the clinical diagnosis of ACS. In addition, the preliminary summary results and 2 illustrative cases from a FDA-IDE (US Food and Drug Administration Investigational Device Exemption) trial evaluating the feasibility of NIRS oximetry as a decision support tool for the diagnosis of ACS are reported.

Methods: The FDA-IDE trial was a prospective observational trial in which subjects were enrolled within 12 hours of severe leg injury or severe trauma not involving the leg. Enrollees underwent a standardized screening and intake and then had NIRS sensors applied to the compartments of each leg and continuous NIRS oximetry values were recorded. Patients with severe leg injuries were observed for up to 48 hours or until they developed ACS. Synchronous data from the injured and noninjured like compartment were compared graphically and statistically. The NIRS values were blinded to the treating providers, and all clinical decision-making was left to standard practice. The primary objective of this preliminary data analysis was to evaluate the feasibility of this approach, as assessed by the time on monitor.

Results: 75 subjects (60 males, average age 39.7 years) were enrolled in the severe leg injury cohort and an additional 23 patients (14 males, average age 36.3 years) were enrolled in the critical control cohort. NIRS data was obtained for at least 2 hours on all patients prior to therapeutic interventions, a median of 40 and 45 hours on monitor for the 2 cohorts, respectively. At least one compartment of the leg could be monitored in all patients for some portion of the study period. An illustrative case demonstrates the hyperemic response, which persisted over the duration of the study period. This hyperemic response is associated with severe leg injury that is not complicated by ACS and has been demonstrated in previous clinical and animal model work.

Conclusion: The reliable and accurate diagnosis of ACS is a critical unmet need in combat casualty care. The ideal solution will leverage technology in the form of physiological monitoring to make or support the diagnosis of ACS. Our preliminary analysis demonstrates that current NIRS oximetry devices can be used to monitor the regional oxygenation of the muscle compartments of the leg in most, but not all, situations. Further development and clinical validation are warranted.

See pages 47 - 108 for financial disclosure information.

Outcomes After Operative Management of Combat-Related Low Lumbar Burst Fractures

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Purpose: Combat-related lumbar burst fractures (53-A3.3) have been documented at an increased incidence during the Iraq and Afghanistan conflicts. Surgical management of these injury patterns is controversial, with high reoperation rates and persistent symptoms frequently reported. We set out to report the intermediate outcomes of service members with operatively managed low lumbar fractures.

Methods: A retrospective analysis of a surgical database at three military institutions was performed; patients undergoing spine surgery designated in as engaged in Operations Enduring and/or Iraqi Freedom between July 1, 2003 and July 1, 2013 were included. Medical records and radiographs were reviewed for all patients treated with combat-related lumbar burst fractures (L3-L5). We included all patients who underwent operative fixation in-theater or at our institution.

Results: 24 patients with an average age of 28.1 ± 67.2 years sustained low lumbar (L3-L5) burst fractures. The average ISS was 22.6. Six patients sustained gunshot wound(s), 15 sustained blast injuries from an improvised explosive device, in addition to one crush and one motor vehicle accident injury. The average number of thoracolumbar levels injured was 2.9 ± 1.4. Nine patients had evidence of neurologic injury, three of which were complete. The average number of levels fused was 4.3 ± 2.1 with fixation extending to the pelvis in four patients (17%). Ten acute postoperative complications occurred; seven required reoperation. One patient required late reoperation for nonunion. Average clinical follow-up was 3.3 ± 2.2 years. At latest follow-up, all were retired from military service or were undergoing separation, 10 (43%) experienced persistent bowel/bladder dysfunction, 15 (65%) had persistent neurologic symptoms, 17 (74%) had documented persistent low back pain, and 19 (83%) had chronic pain.

Conclusion: Low lumbar burst fractures are rare injuries with an increased incidence in current combat casualties. Few studies have examined the intermediate outcomes after operative management of these injury patterns. We found a high rate of acute postoperative complications (43%), low back pain, and a high reoperation rate (30%). At over 3 years average follow-up, most patients with operatively treated low lumbar burst fractures had persistent neurologic symptoms and chronic pain, suggestive that surgical management of low lumbar burst fractures is fraught with complications.

Outcomes of Open Acetabular Fractures in Combat-Related Trauma

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POSTER ABSTRACTS

Background/Purpose: Since the onset of the Global War on Terror, close to 50,000 United States service members have been injured in combat; many of these injuries would have previously been fatal. Among these injuries, open acetabular fractures are at an increased number due to the high percentage of penetrating injuries such as high-velocity gunshot wounds and blast injuries. Blast and ballistic injuries lead to a greater degree of contamination, and more severe associated injuries. There is a significantly smaller proportion of the classic blunt trauma mechanism typically seen in civilian trauma.

Methods: We performed a retrospective review of the Department of Defense Trauma Registry into which all our combat-injured patients are enrolled, as well as local patient medical records, and radiologic studies from March 1, 2003 to April 30, 2012. 85 acetabular fractures were identified with 33 of those fractures being classified as open fractures. Information regarding mechanism of injury, fracture pattern, transfusion requirements, ISS, and presence of lower extremity amputations were analyzed. Results are presented as medians with interquartile ranges (IQRs).

Results: The mechanism of injury was an explosive device in 60% of patients with an open fracture; the remaining 40% were secondary to ballistic injuries. Our closed injury cohort, however, reported a 34% blast injury rate with the remainder of the patients sustaining blunt injury from falls, motor vehicle collisions, or aircraft crashes. Patients with open acetabular fractures required a median of 18 (IQR 5-30) units of PRBC (packed red blood cells) within the first 24 hours after injury. The mean ISS was 31 (IQR 24-35) in the open group compared with 22 (IQR 9-30) in the closed group. Three patients were noted to have bilateral acetabular fractures in the open group with 24% of open fractures being classified as associated patterns. Nine patients (27%) sustained bilateral lower extremity amputations with 8 (89%) of those patients having either a hip disarticulation (n = 4) or hemipelvectomy (n =4) as one of their final amputation levels in the open fracture group. The open group required a mean of 10 procedures (IQR 4-13) to treat their fracture compared to a mean of 1 procedure (IQR 0-2) in the closed group.

Conclusion: Open acetabular fractures represent a major treatment challenge in the management of severe, combat-related injuries. High Injury Severity Scores and massive transfusions are common secondary to the mechanism of injury involved. Our series of 85 combat-related acetabular fractures including 33 open acetabular fractures is one of the largest series on record of open acetabular fractures. Open acetabular fractures frequently require massive initial transfusions and multiple procedures due to the severe soft-tissue injury seen in these patients. The dramatic increase in the percentage of open acetabular fractures at 39% in this review highlights the challenge in treatment of acetabular fractures in combat-related injuries.

See pages 47 - 108 for financial disclosure information.

Outcomes of Open Pelvic Ring Fractures in Combat-Related Trauma

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Background/Purpose: Since the beginning of the current conflicts in Iraq and Afghanistan, United States service members have been surviving combat-related injuries that previously would have been fatal. Resultant from this increased survival rate are high-energy traumatic injuries to the musculoskeletal system not seen in civilian trauma. Among the injuries that are dramatically different from civilian trauma are pelvic ring fractures. The mechanism of injury seen in combat-related pelvic ring injuries is more likely to be a penetrating injury such as a gunshot wound or blast injury. This leads to a higher percentage of open pelvis injuries, a greater degree of contamination, and more severe associated injuries.

Methods: We performed a retrospective review of the Department of Defense Trauma Registry into which all our combat-injured patients are enrolled, as well as local patient medical records, and radiologic studies from March 1, 2003 to April 30, 2012. 116 pelvic ring fractures were identified with 38 of those fractures being classified as open fractures. Information regarding mechanism of injury, fracture pattern, transfusion requirements, ISS, and presence of lower extremity amputations were analyzed. Results are presented as medians with interquartile ranges (IQR).

Results: The mechanism of injury was an explosive device in 92% of patients with an open fracture compared to 64% of our closed fracture group. Patients with open pelvic ring disruption required a median of 29 (IQR 14-40) units of PRBC (packed red blood cells) within the first 24 hours after injury. The mean ISS was 35 (IQR 29-42) in the open group compared with 30 (IQR 22-36) in the closed group. 23 patients (61%) sustained bilateral lower extremity amputations with 10 (43%) of those patients having either a hip disarticulation (n = 4) or hemipelvectomy (n = 6) as one of their final amputation levels in the open fracture group. It is also of note that 29% of the open group was positive for invasive fungal infection and the six who underwent hemipelvectomy all had positive cultures for mold. Furthermore, the open pelvic fracture group experienced an 8% fatality rate in patients that returned to the United States.

Conclusion: Pelvic ring injuries sustained in combat represent a major treatment challenge because of their high percentage of open injuries. Massive transfusions are frequently required and bilateral lower extremity amputations are common secondary to a high-energy mechanism of injury. Our series of 116 combat-related pelvic ring injuries with 38 open pelvic ring fractures is one of the largest series of open pelvic fractures on record. A mortality rate of 8% once these patients reach the United States compares favorably to mortality rates seen in civilian trauma. The mechanism of injury and constellation of associated injuries such as amputations lead to a significant challenge in both the resuscitation as well as long-term rehabilitation of these patients.

Risk Factors for Amputation in Combat-Related Tibia Injuries

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Purpose: The current conflicts in Iraq and Afghanistan represent the longest sustained U.S. armed conflicts in history. As of September 1, 2014, 1573 individual service members have sustained combat-related major limb amputations. Despite the high volume of combat-related amputations, there is no current treatment algorithm to guide the orthopaedic surgeon caring for high-energy lower extremity fractures in the acute or sub-acute in the present study. The purpose of this study is to describe the risk factors for amputation in combat-related fractures of the tibia resulting from injuries sustained in OIF (Operation Iraqi Freedom)/OND (Operation New Dawn)/OEF (Operation Enduring Freedom).

Methods: A retrospective review was conducted using the surgical scheduling system to identify patients who sustained tibia injuries from OIF and OEF. 176 patients with 195 tibia injuries were included for review of 65 distinct demographic and perioperative variables. Data were compiled and analyzed using Student t test for continuous data, and both Fisher exact test and chi-square for categorical data. Significance was set at a P value of <0.05.

Results: There was an amputation rate of 19.4% in this cohort. Age, gender, military service, tobacco use, mechanism of injury, days spent in the intensive care unit, days to fasciotomy closure, total transfusions, use of negative pressure wound dressing, size of segmental tibial defect, positive admission or downrange wound culture, nerve injury, infection within 6 weeks, positive deep vein thrombosis or pulmonary embolism, and heterotopic ossification were not associated with failed limb salvage on univariate analysis. Factors associated with failed limb salvage included the type of definitive fixation utilized in the treatment of tibia fractures (P = 0.009), time to definitive fixation (P <0.0001), Gustilo-Anderson classification (P <0.0004), type of bone graft (P = 0.023), the need for fasciotomy (P = 0.011), presence of a segmental bone defect (P = 0.043), vascular injury (P <0.0001), the need for a flap (P = 0.016), and culture-confirmed soft-tissue infection or osteomyelitis 6 weeks after definitive fixation (P <0.0001). Multivariate analysis elucidated vascular injury (odds ratio [OR], 3.25; 95% confidence interval [CI], 1.11-9.49; P = 0.031) and culture-confirmed soft-tissue infection or osteomyelitis (OR, 6.56; 95% CI, 2.24-19.24; P = 0.001) as independent predictors of amputation.

Conclusion: To our knowledge, this is the largest and most comprehensive series in the war trauma literature to describe risk factors for amputation in the combat-related tibia injury. Vascular injury and soft-tissue infection or osteomyelitis 6 weeks after definitive fixation were identified as independent risk factors for amputation.

See pages 47 - 108 for financial disclosure information.

Combat Periarticular Tibia Injury Outcome Study (CAPTIOUS): Risk Factors for Reoperation and Amputation After Open Periarticular Tibia Fractures

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Purpose: Combat-related open periarticular tibia fractures are complex injuries that are frequently coupled with concomitant injuries. The purpose of this report is to identify risk factors for reoperations and amputation in patients with combat-related periarticular tibia fractures.

Methods: After obtaining IRB approval, a retrospective review was conducted of all patients who sustained a combat-related periarticular tibia (plafond and plateau) fracture during Operation Enduring Freedom and Operation Iraqi Freedom between 2003 and 2011. The institution's electronic medical records system and the armed forces Joint Trauma Registry (JTR) were queried and collected data included patient characteristics, injury patterns, treatment modalities, reoperation rates, complications, and outcomes. Logistic regression analysis with reoperations and amputation as the main outcome measures against injury and treatment characteristics were performed to identify significant predictors of delayed amputation.

Results: 145 patients sustained 146 combat-related periarticular tibia fractures (66 pilon, 80 plateau) during the time period observed. The mean age was 26.7 ± 6.8 years, with the majority (86%) of fractures the result of a blast mechanism. 64% (92/146) of the injuries were open fractures (67 IIIa, 18 IIIb, 7 IIIc). Flap coverage was performed in 18 cases (9 pedicle, 9 free). 55% percent of the extremities had ipsilateral fractures (81/146) with the calcaneus (19) and distal femur (18) being the most common location. Open reduction and internal fixation was the primary mode of fixation in 80% of the fractures with the remaining fractures definitively treated with external fixation or hybrid fixation. The overall deep infection rate was 23% (34/146) with 73% (25/34) of the deep infections occurring in the open fractures. The organisms most frequently implicated as the cause of deep infection in the open fractures were Acinetobacter and E-Coli. For the nine closed fractures complicated by infection, gram-positive organisms were primarily implicated (methicillin-resistant Staphylococcus aureus [MRSA], methicillin-sensitive S. aureus [MSSA], and group B Streptococcus). Radiographic evidence of posttraumatic osteoarthritis occurred in 46% (67/146) of the injuries (43 pilon, 24 plateau). Over 61% (89/146) of the fractures required reoperation for complications after definitive closure ($P < 0.005$). The most common cause for early reoperation was due to the development of a deep infection ($P < 0.01$). The most common cause for late operation was secondary to the development of posttraumatic osteoarthritis. The overall delayed amputation rate was 18% (26/146) and 36% (9/25) of the open fractures complicated by infection underwent delayed limb amputation. The majority (62%) of the amputated limbs sustained ipsilateral fractures (16/26). The time from injury to definitive fixation and wound closure averaged 16.25 days and was predictive of delayed amputation ($P < 0.05$). Based on logistic regression analysis the development of a deep infection, time to fixation, and need for reoperation after definitive fixation were found to be independent predictors of late amputation.

Fixation method, ISS, and need for flap had no correlation with reoperation or amputation rate. The overall fracture union rate was 93%.

Conclusion: Open periarticular tibia fractures as a result of combat-related trauma are associated with high complication rates, reoperation rates, and higher than expected delayed amputation rates. These findings are substantially higher than that observed within the reported civilian literature. Based on our study, careful counseling and expectation management must be provided in those war-injured trauma patients with open periarticular fractures undergoing attempts at limb salvage.

See pages 47 - 108 for financial disclosure information.

The Minimal Clinically Important Difference of the Patient-Rated Wrist Evaluation Score for Patients with Distal Radius Fractures: A Prospective Cohort Study

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Purpose: The purpose of this study was to determine the minimal clinically important difference (MCID) of the Patient-Rated Wrist Evaluation (PRWE) score in patients with distal radius fractures.

Methods: We prospectively included 102 patients with a median age of 59 years (interquartile range, 48-66). All participants completed the PRWE questionnaire during two separate visits. Additionally, patients were asked to indicate the degree of clinical change they appreciated on a scale from -5 (much worse) to +5 (much better) through 0 (no change). Accordingly, patients were categorized into two groups: (1) minimally improved or (2) no change. These groups were used to "anchor" the changes observed in the PRWE to patients' perspective of what is clinically important. We determined the MCID according to the ROC (receiver operating characteristic curve) method. In this context, the change in PRWE is considered a diagnostic test and the anchor (minimally improved or no change) is the gold standard. The optimal ROC cutoff point reflects the value of the MCID.

Results: The majority of patients indicated they experienced marked improvement and the PRWE score between the first and the second measurement differed significantly ($P < 0.001$, Wilcoxon signed rank test). The MCID of the PRWE was 11.5 points.

Conclusion: A change of 11.5 points on the PRWE represents a clinically important difference for patients with distal radius fractures. We recommend using this value to interpret treatment effects and for sample size calculations.

Assessment of Pronator Quadratus Repair Integrity Using Dynamic Ultrasonography Following Volar Plate Fixation for Distal Radius Fractures

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Purpose: Previous work evaluating the pronator quadratus muscle (PQ) following volar plate fixation (VPF) of distal radius fractures suggests that the PQ repair often fails in the postoperative period. However, these postoperative evaluations of the PQ have been limited to indirect imaging methods. The purpose of this study was to directly and quantitatively assess the integrity of the PQ after repair following VPF of distal radius fractures using dynamic musculoskeletal ultrasonography. We hypothesized that PQ repair results in a low rate of failure.

Methods: We retrospectively identified patients who underwent VPF by 3 hand surgeons from January 2013 to January 2015. Patients aged 18-90 years with a minimum postoperative follow-up of 3 months were initially included for analysis. Patients with concomitant fractures of the contralateral upper extremity were excluded. Study patients underwent bilateral dynamic wrist ultrasonography by a single fellowship-trained musculoskeletal radiologist. Our primary objective was to determine whether the PQ muscle remained intact as evidenced by complete continuity of the muscle as visualized on ultrasound. Secondary data points included whether the PQ completely covered the volar plate, bilateral PQ volume, bilateral wrist range of motion (ROM), bilateral grip strength, visual analog scale (VAS) for pain, and Disabilities of the Arm, Shoulder and Hand (DASH) score. Age, gender, occupation, mechanism of injury, hand dominance, presence of complications, and length of follow-up were also noted for all subjects. Mann-Whitney U tests were utilized to compare PQ volume, wrist ROM, and grip strength between operative and contralateral nonoperative wrists. A P value <0.05 was considered significant.

Results: 13 patients (7 men and 6 women) underwent bilateral wrist ultrasonography. Mean age was 57 ± 17 years and 92% (12 of 13) were right-hand dominant. 62% (8 of 13) underwent VPF of their dominant wrist. 11 patients sustained their injury secondary to fall, while the remaining 2 patients incurred sports injuries. Patients were evaluated a mean 10 ± 4 months after VPF and demonstrated mean VAS and DASH scores of 0.8 ± 1.3 and 14 ± 16, respectively. Dynamic sonographic assessment revealed an intact PQ repair in all patients with the volar plate completely covered by the PQ in 54% (7 of 13) of patients. Statistical analysis revealed significantly poorer wrist flexion ($P = 0.04$), pronation ($P = 0.009$), and ulnar deviation ($P = 0.007$) in operative wrist compared to the nonoperative wrist. There were no significant differences in PQ volume, extension, supination, radial deviation, and grip strength between wrists (Table 1).

Conclusion: The PQ demonstrates substantial durability after repair following VPF. Although wrist flexion, pronation, and ulnar deviation were significantly decreased in the operative wrist, PQ repair is unlikely to be a factor as PQ volume and grip strength were similar in operative and nonoperative wrists.

See pages 47 - 108 for financial disclosure information.

Table 1.
Comparison of PQ volume, wrist ROM, and grip strength between operative and contralateral nonoperative wrists

Measurement	Units	Operative Wrist	Nonoperative Wrist	P value
PQ volume, (SD)	cm^3	13.5 (7.0)	16.5 (6.6)	0.174
Flexion, (SD)	Degrees	59 (17)	73 (17)	0.04
Extension, (SD)	Degrees	53 (11)	61 (15)	0.119
Pronation, (SD)	Degrees	79 (9)	89 (14)	0.009
Supination, (SD)	Degrees	88 (15)	97 (18)	0.49
Radial deviation, (SD)	Degrees	18 (7)	22 (7)	0.095
Ulnar deviation, (SD)	Degrees	34 (10)	46 (10)	0.007
Grip strength, (SD)	Kg	52 (26)	64 (22)	0.174

Abbreviations: PQ, pronator quadratus; ROM, range of motion, SD, standard deviation.

Bier Block Anesthesia for Distal Radius Fracture Reduction in the ED: Is it Safe?

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Purpose: Intravenous regional anesthesia (Bier block) represents a controversial means of emergency department (ED) analgesia secondary to the potential catastrophic complications associated with its use. Common concerns regarding this method of analgesia are related to the fear of systemic reactions of lidocaine, including severe neurologic and cardiac toxicities. It is not known whether Bier block use affects the rate of complex regional pain syndrome (CRPS) or other neurologic sequelae as compared to historical rates reported in the literature. We sought to define the safety profile of Bier block anesthesia as used in the ED for closed manual reduction of distal radius fractures.

Methods: A retrospective chart review was carried out on all the patients who presented to our tertiary care institution with a distal radius fracture from November 2009 to November 2014. Demographic information, type of anesthesia used for the reduction (conscious sedation, hematoma block, Bier block), complications associated with Bier block, tourniquet time, neurologic examination at final follow-up, and diagnosis of CRPS were all recorded.

Results: A total of 864 patients were treated for a distal radius fracture, of whom 357 underwent manual closed reduction in our ED. Of the 357 patients receiving closed reduction, 37 received conscious sedation, 56 received a hematoma block, and 264 received regional anesthesia via Bier block. Of the 264 identified and included in the study, 4 patients (1%) were noted to have experienced minor complications. These included chest pain (negative cardiac workup), tinnitus and peri-oral numbness (no further neurologic sequelae noted), intolerable tourniquet pain that prevented a Bier block from being used, and acute onset carpal tunnel syndrome that resolved following splint exchange (n = 1 for all complications). Open reduction and internal fixation (ORIF) was required in 125 (47%) of the 264 patients. Average tourniquet time was 30 minutes (range, 20-45). The review identified 5 patients (2%) who went on to develop CRPS, with 2 of the 5 receiving ORIF. All other patients in the series had normal neurologic examinations at their last scheduled follow-up (average follow-up = 109 days).

Conclusion: This series demonstrated that Bier block anesthesia is a safe means of providing analgesia when performing manual closed reduction of distal radius fractures. At our institution Bier block anesthesia was used in 74% (264 of 357) of closed reductions. Only four minor complications were noted in the series with no major neurologic or cardiac toxicities documented. Importantly, only one patient was noted to have significant tourniquet pain; the remainder of the patients in the series had adequate analgesia for manual reduction. The rate of CRPS in this series was noted to be less than historically reported rates in the literature for distal radius fractures (10% to 30%). Additionally, no major long-term adverse neurologic deficits were noted at follow-up evaluation.

See pages 47 - 108 for financial disclosure information.

Can the Visual Analog Scale Be Used as a Long-Term Outcome Instrument to Track Pain Severity in Orthopaedic Patients?

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Background/Purpose: The chief complaint of most orthopaedic patients is pain; as such, change in pain severity has become the primary outcome of many studies. Currently, most studies assess patients' pain using a visual analog scale (VAS) yielding a "pain score" that is routinely used to track pain severity over time. Advocates of the VAS argue that it allows for more discrete measurements, while its opponents claim that a Likert scale is easier to administer. The literature has shown that in short-term periods of less than 24 hours, the VAS and Likert-based scales are equal to one another in terms of statistical results. However, a scarce amount of research has been done to examine the comparativeness of the two scales in periods ranging from weeks to months. We hypothesize that using a VAS as a long-term measure of patients' pain will correlate poorly with their long-term perceived change in pain. Therefore, we assessed the correlation of patients' change in pain measured using a VAS versus their perceived change in pain using a Likert scale.

Methods: Retrospective review was performed of prospectively collected data on all distal radius fractures (DRFs) treated at our institution from 2010-2012 with patients that gave informed consent. At the initial and each follow-up visit, patients used a VAS to indicate their level of pain at rest (VAS-Rest) and when actively using the injured extremity (VAS-Active). At follow-up visits, patients answered a question that asked: "how do you feel that your pain has changed since your last orthopaedic clinical visit?" This "change in pain" (CP) question consisted of a 5-level Likert item. Patients' pain data points were grouped into independent data sets consisting of 3 data points (VAS-Rest, VAS-Active, and CP). Incomplete data sets were excluded. Then, the difference in VAS pain scores between consecutive visits and the CP score were compared using Spearman's correlation coefficient. A P value of less than 0.05 was considered significant.

Results: 98 patients suffering a DRF were included in this study. Among these, 24 were excluded due to incomplete data sets. A total of 74 patients (54 females, 20 males) with 238 VAS-Rest, 238 VAS-Active, and 119 CP scores were then analyzed. Mean patient age was 54 years (range, 19-82 years). Mean time interval between pain severity scores was 3.16 months, and mean total follow-up time (first to last visit) was 6.85 months. Spearman coefficient showed weak correlation between patients' CP score, and VAS-Rest and VAS-Active pain scores ($r = 0.237$ and $r = 0.251$, respectively [$P = 0.01$]).

Conclusion: The results of this study show that the commonly used VAS may be a poor measure for assessing patients' long-term pain. This is highlighted by the poor correlation the difference in VAS pain scores between visits has with CP score. Additionally, since previous studies have indicated that the clinical context and setting of the evaluation of pain scales are influential in determining the reliability and responsiveness of these scales, our results direct attention to the need for further research (conducted in a variety of clinical settings) into the long-term reliability of the VAS. These studies should also assess the correlation each of these scores has with physiologic markers appropriate to the clinical context. This will help determine if a more consistent pain severity measure and/or a shift away from a VAS as the primary pain measure is needed for research that more accurately assesses orthopaedic treatment outcomes.

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Database Project Team
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Research Think Tank
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OTA ORTHOPAEDIC TRAUMA ASSOCIATION

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.

John States, MD (2015)
Rochester, New York

CENTER FOR ORTHOPAEDIC TRAUMA ADVANCEMENT ACKNOWLEDGMENTS

COTA 2015-2016 Academic Year Fellowship Programs Awards:

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

Carolinas Medical Center, Charlotte, NC
– *Madhav Karunaker, MD, Director*

Harvard Orthopedic Trauma, Department of Orthopaedic Surgery, Boston, MA
– *Michael Weaver, MD, Director*

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– *Eben Carroll, MD, Director*

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

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Georgia Orthopaedic Trauma Institute
– Lawrence Webb, MD

Indiana University Methodist Hospital
– Anthony Sorkin, MD

Los Angeles County, USC Medical Center
– Jackson Lee, MD

Orthopaedic Trauma Surgeons of Northern California
– Paul Gregory, Jr., MD

San Diego Trauma Fellowship
– Jeffrey Smith, MD

Sonoran Orthopaedic Trauma Surgeons
– Anthony Rhorer, MD

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Stanford University Orthopaedic Trauma Fellowship
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– Thomas DeCoster, MD

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– Brent Norris, MD

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CONGRATULATIONS
2014-2015 OTA Fellowship Graduating Class:

Ellen Fitzpatrick, MD and **James Hlavacek, MD**
Allegheny General Hospital, Drexel University College of Medicine, Pittsburgh, PA
– *Daniel T. Altman, MD, Director*

Daniel Bazylewicz, MD, **Cassandra Dielwart, MD** and **Bryan Ming, MD**
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A special thank you to Industry Partners:
Smith & Nephew, Stryker, DePuy Synthes and Medtronic.

AWARDS

MEMORIAL AWARD WINNER

OTA honors the memory of the orthopaedic traumatologists and their commitment to education, research and patient care.

2014 – ***David Ding, MD, Resident Award Winner***
Continuous Popliteal Sciatic Nerve Block for Ankle Fractures Reduces Postoperative Opioid Requirements and Rebound Pain: A Prospective Randomized Comparative Trial
David Ding, MD; Arthur Manoli III, BS; David Galos, MD; Sudheer Jain, MD;
Nirmal C. Tejwani, MD, FRCS;
NYU Langone Medical Center Hospital for Joint Diseases, New York, New York, USA

OTA/SIGN SCHOLARSHIP

The Orthopaedic Trauma Association funds 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:

2015 – ***Dr. Saju Pradhan, MBBS D ORTHO FRCOST****, Nepal Orthopaedic Hospital, Kathmandu, Nepal*
Bhaskar Raj Pant, MD*, Grande International Hospital, Kathmandu, Nepal*

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.

2014 – Long Term Careers in Orthopaedic Trauma:
System Design and Career Development
Andrew R. Burgess, MD

EDWIN G. BOVILL, Jr., MD AWARD WINNER

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

2014 – Continuous Popliteal Sciatic Nerve Block for Ankle Fractures Reduces Postoperative Opioid Requirements and Rebound Pain:
A Prospective Randomized Comparative Trial
David Ding, MD; Arthur Manoli III, BS; David Galos, MD; Sudheer Jain, MD;
Nirmal C. Tejwani, MD, FRCS;
NYU Langone Medical Center Hospital for Joint Diseases, New York, New York, USA

OTA 2015 RESEARCH GRANT AWARD RECIPIENTS

(January 1, 2015 - December 31, 2015 Grant Cycle)

CLINICAL GRANT AWARDS (up to $40,000/year, 2 year grant cycle)

Title: **Treatment of Periprosthetic Distal Femur Fractures: A Randomized Controlled Trial of Locking Plate Osteosynthesis versus Retrograde Intramedullary Nailing**
Principal Investigator: **Aaron Nauth, MD, FRCSC**
Co-Principal Investigator: **Emil Schemitsch, MD, FRCSC**
Awarded Funds: **$78,749** Grant Funded By: **Zimmer / OTA**

Title: **Registry for Orthopaedic Trauma in Children (ROTC)**
Principal Investigator: **Kelly VanderHave, MD**
Awarded Funds: **$79,495** Grant Funded By: **Cardinal Health / OTA**

BASIC RESEARCH GRANT AWARDS (up to $50,000 with $25,000/year max up to 2-year grant cycle)

Title: **Bone Regeneration in Spaceflight**
Principal Investigator: **Melissa Kacena, PhD**
Co-Principal Investigators: **Todd McKinley, MD**
Awarded Funds: **$50,000** Grant Funded By: **OTA**

Title: **Suppression of Trauma-Induced Systemic Inflammation**
Principal Investigator: **Dominik Haudenschild, PhD**
Co-Principal Investigator: **Mark Lee, MD**
Awarded Funds: **$50,000** Grant Funded By: **DePuy Synthes Trauma / OTA**

Title: **The Use of Thrombopoietin with Autologous Minced Muscle Grafts for the Repair of Volumetric Muscle Loss**
Principal Investigator: **Benjamin Corona, PhD**
Co-Principal Investigator: **Todd McKinley, MD**
Awarded Funds: **$50,000** Grant Funded By: **OTA**

Title: **The Ossabaw Pig as a Musculoskeletal Model for Type II Diabetes**
Principal Investigator: **Robert Welch, DVM, PhD**
Co-Principal Investigator: **Adam Starr, MD**
Awarded Funds: **$47,874** Grant Funded By: **OTA**

2015 DIRECTED TOPIC: National Trauma Data Bank Grant Award Recipients

Title: **Comparison of Study Results Between the National Trauma Data Bank (NTDB) and Trauma Quality Improvement Program (TQIP): A Study of Femoral Diaphyseal Fractures**
Principal Investigator: **Jonathan Grauer, MD**
Co-Principal Investigator: **Michael Leslie, DO**
Awarded Funds: **$3,850**

Title: **Trauma Centers and Socioeconomic Status: Is the Mortality Benefit of Trauma Center Treatment Maintained Across Socioeconomic Strata**
Principal Investigator: **Erik McDonald, MD**
Co-Principal Investigator: **Saam Morshed, MD, PhD, MPH**
Awarded Funds: **$16,870**

OTA 2015 RESEARCH GRANT AWARD RECIPIENTS, continued

2015 CORPORATE DIRECTED TOPIC: Syndesmotic Injuries Grant Recipient

Title: **A Prospective Randomized Multi-Center Study to Compare Open Reduction, Tight Rope Fixation (OT) versus Open Reduction Screw Fixation (OS) of the Tibio-Fibular Syndesmosis**
Principal Investigator: **David Sanders, MD**
Co-Principal Investigator: **Abdel-Rahman Lawendy, MD**
Awarded Funds: **$100,000** Grant Funded By: **Arthrex**

2015 RESIDENT GRANT RECIPIENTS (up to $20,000)

Title: **What is the Effect of Antibiotic-Impregnated Bone Cement Spacers in the Healing Process of Large Bone Defects as Part of the Masquelet Technique?**
Principal Investigator: **Evan Watts, MD**
Co-Principal Investigator: **Emil Schemitsch, MD**
Awarded Funds: **$20,000** Grant Funded By: **OTA**

Title: **Bioelectrical Impedance in the Assessment of Fracture Healing**
Principal Investigator: **Anthony Shyn Ding, MD**
Co-Principal Investigator: **Meir Marmor, MD**
Awarded Funds: **$20,000** Grant Funded By: **OTA**

Title: **Tension Plate Versus Cannulated Anterior Tension Band Fixation for Patella Fractures: A Biomechanical Study**
Principal Investigator: **Daniel Elkin, MD**
Co-Principal Investigator: **Michael Sirkin, MD**
Awarded Funds: **$17,967** Grant Funded By: **FOT / OTA**

Title: **A Retrospective Cohort Study of Short and Long-Term Reoperation Rates After Proximal Humerus Fracture Management in the Elderly**
Principal Investigator: **Marissa E. Bonyun, MD, MEd**
Co-Principal Investigator: **Michael D. McKee, MD, FRCSC**
Awarded Funds: **$19,600** Grant Funded By: **FOT / OTA**

Title: **Frailty, Sarcopenia and Outcomes in Orthopaedic Trauma Patients**
Principal Investigator: **Basel Touban, MD**
Co-Principal Investigator: **Mark Anders, MD**
Awarded Funds: **$9,757** Grant Funded By: **OTA**

OTA 2015 RESIDENT GRANT RECIPIENTS

(June 1, 2015 - May 31, 2016 Grant Cycle)

Grant Title: **The Biomechanics of Fixation via the Modified Stoppa Approach vs. the Posterior Approach for Management of Acetabular Fractures with ORIF and Acute THA in the Elderly**
Principal Investigator: **Joel Moktar, MD**
Co-Investigator: **Radovan Zdero, PhD**
Amount Funded: **$20,000** Grant Funded by: **OTA**

Grant Title: **Tracking Longitudinal Radiation Exposure in Orthopaedic Surgeons and Orthopaedic Residents: What Dose Are We Getting?**
Principal Investigator: **Elizabeth B. Gausden, MD**
Co-Investigator: **Joseph M. Lane, MD**
Amount Funded: **$10,000** Grant Funded by: **OTA**

Grant Title: **Contributing Factors to Short and Long-Term Reoperation After Surgical Treatment of Ankle Fracture**
Principal Investigator: **Thomas Zochowski, MD, MSc**
Co-Investigator: **Andrea Veljkovic, MD, MSc**
Amount Funded: **$18,500** Grant Funded by: **OTA**

Grant Title: **What is the Optimal Timing for Cessation of Smoking to Reduce the Impact on Bone Healing?**
Principal Investigator: **Jeremy Truntzer, MD**
Co-Investigator: **Christopher Born, MD**
Amount Funded: **$20,000** Grant Funded by: **OTA**

Grant Title: **Does Early Platelet Rich Plasma Injection Decrease the Risk of Post-Traumatic Arthritis in Pilon Fractures Undergoing Two-Staged Open Reduction and Internal Fixation?**
Principal Investigator: **Christopher R. James, MD**
Co-Investigator: **Brett Crist, MD**
Amount Funded: **$20,000** Grant Funded by: **OTA**

Grant Title: **Accuracy and Reliability of Using Fluoroscopic Landmarks to Control Tibial Rotation During Intramedullary Fixation of Tibial Shaft Fractures**
Principal Investigator: **Calvin L. Schlepp, MD**
Co-Investigator: **David Barei, MD**
Amount Funded: **$16,000** Grant Funded by: **OTA**

Grant Title: **The Severity of Compartment Syndrome-Associated Microvascular Dysfunction May Be Diminished by the Neutralization of Pro-Inflammatory Cytokines**
Principal Investigator: **Erin Donohoe, MD**
Co-Investigator: **Abdel-Rahman Lawendy, MD**
Amount Funded: **$20,000** Grant Funded by: **OTA**

Grant Title: **A Novel Macrophage Targeting MRI Contrast Molecule for Diagnosis of Chronic Posttraumatic Osteomyelitis**
Principal Investigator: **Joshua Li, MD, PhD**
Co-Investigator: **David B. Weiss, MD**
Amount Funded: **$20,000** Grant Funded by: **OTA**

TOTAL RESIDENT GRANTS AWARDED: **$144,500**

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. This 31st Anniversary 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. Ample opportunity will be available for expression of common concerns, sharing of relevant experiences, and discussion of alternative treatment approaches.

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 **23.25** ***AMA PRA Category 1 Credits***™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

ACCREDITATION – CME INFORMATION

The Basic Science Focus Forum has been planned and implemented in accordance with the accreditation requirements and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership 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 **11.25** ***AMA PRA Category 1 Credits***™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

The 31st Annual Meeting of the Orthopaedic Trauma Association has been planned and implemented in accordance with the accreditation requirements and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of the American Academy of Orthopaedic Surgeons and 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 **23.25** ***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 31st 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.

DISCLAIMER

The material presented at the 31st 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 31st 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.

ORTHOPAEDIC —TRAUMA— ASSOCIATION

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.

OTA GRATEFULLY ACKNOWLEDGES
THE FOLLOWING EXHIBITORS
FOR THEIR SUPPORT OF THE 31ST ANNUAL MEETING:

Booth #	Company Names	City, State
908	**Aap Implantate AG**	Berlin, Germany
217	**Acumed**	Hillsboro, OR
314	**Advanced Orthopaedic Solutions**	Torrance, CA
106	**Advent Orthopaedics**	Waco, TX
302	**AO Trauma North America**	Paoli, PA
710	**Arthrex Inc.**	Naples, FL
Seaport Foyer	**Augmented Reality Systems, Inc**	Windham, NH
907	**BioAccess, Inc**	Baltimore, MD
814	**Biocomposites Inc.**	Wilmington, NC
215	**Bionova Medical, Inc.**	Germantown, TN
407	**Bioventus LLC**	Durham, NC
310	**Bone Foam Inc.**	Plymouth, MN
304	**Breg, Inc.**	Carlsbad, CA
719	**Carbofix Orthopedics, Inc.**	Collierville, TN
912	**Carestream Health**	Rochester, NY
903	**CFI Medical**	Fenton, MI
202	**Citieffe Inc.**	Eads, TN
807	**Conventus Orthopaedics**	Maple Grove, MN
702	**Depuy Synthes**	West Chester, PA
803	**DJO, Inc.**	Vista, CA
204	**ECA Medical**	Thousand Oaks, CA
802	**Ellipse Technologies Inc**	Irvine, CA
906	**Emcare Acute Care Surgery**	Dallas, TX
107	**Enova Illumination**	Saint Paul, MN
103	**FX Devices**	Boca Raton, FL
904	**Gauthier Biomedical, Inc.**	Grafton, WI
916	**Halyard Health**	Irvine, CA
804	**Inion Inc**	Weston, FL
320	**Innomed Inc.**	Savannah, GA
808	**Innovision, Inc.**	Memphis, TN
902	**International Instruments**	Raleigh, NC
715	**Invibio**	Conshohocken, PA
910	**Invuity Inc**	San Francisco, CA
402	**ITS. USA**	Maitland, FL
716	**KCI, An Acelity Company**	San Antonio, TX
809	**Lilly USA, LLC.**	Indianapolis, IN
221	**Medartis**	Exton, PA
711	**Medtronic Spinal and Biologics**	Memphis, TN

EXHIBITORS LISTING, continued

Booth #	Company Names	City, State
108	**Microware Precision Co Ltd**	Logan, UT
102	**Mizuho OSI**	Union City, CA
712	**New Clip Technics**	Haute-Goulaine, France
815	**Orthofix**	Lewisville, TX
709	**Orthogrid Systems, LLC**	Woods Cross, UT
109	**Pacific Instruments**	Honolulu, HI
816	**Pacira Pharmaceuticals**	Parsippany, NJ
306	**PFS Med, Inc**	Springfield, OR
208	**Pikeville Medical Center, Inc.**	Pikeville, KY
818	**Quintus Composites**	Camp Verde, AZ
714	**Sawbones/Pacific Research Labs**	Vashon, WA
318	**Sectra**	Linköping, Sweden
211	**Si-Bone, Inc.**	San Jose, CA
911	**Siemens Medical Solutions USA**	Malvern, PA
105	**Skeletal Dynamics**	Miami, FL
813	**Skeletal Kinetics**	Cupertino, CA
502	**Smith & Nephew, Inc.**	Cordova, TN
913	**Stabiliz Orthopaedics**	Exton, PA
905	**Starr Frame LLC**	Richardson, TX
516	**Stryker**	Mahwah, NJ
909	**Synergy Surgicalists**	Bozeman, MT
213	**The Journal of Bone & Joint Surgery**	Needham, MA
806	**The Orthopaedic Implant Company**	Reno, NV
810	**TriMed, Inc.**	Santa Clarita, CA
917	**Truemed Group, LLC**	Houston, TX
919	**Vivorte, Inc.**	Louisville, KY
Palm Foyer	**Wolters Kluwer Health | Lippincott Williams & Wilkins**	Philadelphia, PA
104	**Wound Care Technologies, Inc.**	Chanhassen, MN
915	**Wright Medical Technology**	Memphis, TN
718	**X-Bolt Orthopaedics**	Bristol,
101	**Ziehm Imaging**	Orlando, FL
416	**Zimmer Biomet**	Warsaw, IN
817	**Zyga Technology, Inc.**	Minnetonka, MN

EXHIBITORS