William M. Ricci, MD

In 1998, I attended my very first OTA Annual Meeting in Vancouver. Nineteen years later, as OTA President, I welcome you to 33rd Orthopaedic Trauma Association Annual Meeting in Vancouver, British Columbia. Please enjoy some of the parallels between the growth and maturity of the city of Vancouver and the Orthopaedic Trauma Association.

Since 1998, OTA membership has grown from 323 to 2,029. We now have 10 membership categories (compared to 4 in 1998) with international member growth outpacing all others. We welcome a record numbers of international attendees, especially from Asia (due to proximity), from our Guest Nation the United Kingdom, and SIGN scholars from the Philippines and Uganda. Just as membership has seen substantial growth, the OTA Annual Meeting has grown substantially in size and scope in the past two decades:

	Vancouver 1998	Vancouver 2017
Attendees	564	1,581 anticipated
Submitted Abstracts	350	950
Podium Presentations	76	96
Poster Presentations	108	179
Main Symposia	None	3
International Forum	None	Yes
Guest Nation	None	United Kingdom
Breakout Sessions	5	38
Industry Exhibitors	38	61
Pre-Meeting Events		
Coding Course	No	Yes
Basic Science Forum	No	Yes
Boot Camp	No	Yes
PA / NP Course	No	Yes
Residents Course	Yes	Yes
Young Practitioners Forum	No	Yes
Industry Symposia	No	Yes

Don't miss the 2017 Border Lecture, "Observations in Innovation", by our Past President Roy Sanders. Other noteworthy events include the charter signing for the new International Orthopaedic Trauma Association, a consortium of international societies, on Wednesday evening. Many behind the scenes meetings of our various committees and leadership will help shape the future of our organization with updates presented at our Business Meeting on Thursday, October 12 at 5:10 pm. Finally, and importantly, please be sure to visit the exhibit hall often where our industry partners will be presenting their latest innovations.

The tireless work of our membership, staff, and partners over the past two decades has created a world-class meeting where practitioners at all levels from around the globe come to be updated on the latest in our field. Many special thanks to Mike McKee and Mike Gardner and the entire Program Committee, our local hosts Pierre Guy, Kelly Lefaivre, and Peter O'Brien, OTA staff and all others for putting together another fantastic and innovative program. Clearly, this is a very special meeting for me. I hope it will be a great learning and personal experience, connecting with friends and colleagues, for you as well. Enjoy the meeting!

Sincerely,

William M. Ricci, MD
President, Orthopaedic Trauma Association

Welcome

Find a Surgeon

OTA Membership Directory available at www.ota.org.
Search by name or location. Directory updated weekly.
Email addresses available via the 'Members Only' page.

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Home Page: www.ota.org

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SCIENTIFIC POSTERS *West Exhibit Hall B*
and **TECHNICAL EXHIBITS**
(See Scientific Posters on pages 221 - 399; Exhibitor Listing on pages 471-472)

Open:	Thursday	2:30 pm	-	6:30 pm
	Friday	7:00 am	-	10:00 am
		12:10 pm	-	1:10 pm
		3:00 pm	-	6:15 pm
	Saturday	7:00 am	-	1:45 pm

SPEAKER READY ROOM *West Meeting Room 103*

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

OTA VIDEO SHOWCASE *Ballroom Foyer (Outside the General Session Room)*

Open	Wednesday	12:00 pm - 5:00 pm
	Thursday thru Saturday	6:30 am - 5:00 pm

NOTE: Cameras (including cell phone 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 September 12, 2017)

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Thank You

OTA Legacy Society

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Kathy Cramer, MD (Deceased)
Thomas (Toney) A. Russell, MD

The OTA is pleased to honor the following individuals and organizations who have reached a lifetime giving level of $10,000 or greater.

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ACKNOWLEDGMENTS

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ORTHOPAEDIC TRAUMA ASSOCIATION

2017 BASIC SCIENCE FOCUS FORUM

October 11-12, 2017

(West Meeting Room 109-110)

Basic Science Committee

Edward J. Harvey, MD, Chair
Michael T. Archdeacon, MD
Mohit Bhandari, MD, PhD, FRCSC
Joseph Borrelli Jr., MD
Brett Crist, MD
Todd O. McKinley, MD
Tyler Morris, MD
Aaron Nauth, MD
Emil H. Schemitsch, MD

Learning Objectives

Upon successful completion of this course, participants will be able to:

- Outline the biomechanical principles of injury
- Understand the implications of joint impact injuries
- Comprehend the clinical outcome scores used in orthopaedic research
- Discover new options for treatment of infection
- Explore the basic science and clinical outcomes of pain medication and their prescriptions
- Understand current concepts in tissue engineering.

The American Academy of Orthopaedic Surgeons designates this live activityfor a maximum of **11.75** ***AMA PRA Category 1 Credits***™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

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ORTHOPAEDIC TRAUMA ASSOCIATION

2017 BASIC SCIENCE FOCUS FORUM

Wednesday, October 11, 2017

(West Meeting Room 109-110)

6:00 am **Speaker Ready Room**
(West Meeting Room 103)

6:30 am **Registration**

Continental Breakfast
(West Meeting Room Lobby – Outside Meeting Room)

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

7:35 – 8:45 am **SYMPOSIUM 1: BIOMECHANICS-INJURY BIOMECHANICS OF FRACTURES**

Moderators: *Pierre Guy, MD*
Peter Cripton, PhD

7:35 am **Introduction: The Test Case of Hip Fractures**
Pierre Guy, MD

7:40 am **How Bones Fail: Injury Biomechanics Primer**
Peter Cripton, PhD

7:53 am **From Finite Elements to Clinical Use: Biofidelic Models for Hip Fracture Risk Screening**
Benedikt Helgason, PhD

8:06 am **The Classics: In Vitro Stress and Fracture Under Different Loading Conditions**
Luca Cristofolini, PhD

8:19 am **Accounting for Reality: Biofidelic Simulations of the Sideways Fall Impact**
Ingmar Fleps, MSc

8:32 am Summary and Questions
Pierre Guy, MD

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

See pages 401 - 442 for financial disclosure information.

8:45 – 9:24 am

PAPER SESSION 1: APPLIED BIOMECHANICS

Moderators: *Pierre Guy, MD*
Peter Cripton, PhD

8:45 am — **Overview**
Pierre Guy, MD

8:50 am (p. 59) PAPER #1 — **Do Promising Biomechanical Research Studies Lead to Clinically Meaningful Results?**
*Jason R. Kang, MD; **Grace Xiong**; Julius A. Bishop, MD*

8:56 am (p. 60) PAPER #2 — **Δ Validation of the Radiographic Union Score for Tibial Fractures (RUST) Using Medical Imaging and Biomechanical Testing in an In-Vivo Rat Model**
*Sandra Fiset, MSc; Meghan C. Crookshank, MD; Charles Godbout, PhD; Radovan Zdero, PhD; Aaron Nauth, MD; **Emil H. Schemitsch, MD***

9:02 am (p. 61) PAPER #3 — **Long Segment Blocking Screws (LSBS) Increase Stability of Retrograde Nail Fixation in Geriatric Supracondylar Femur Fractures: Eliminating the "Bell-Clapper Effect"**
***David Donohue**; Darryl A. Auston; Kyle Stoops; Miguel Diaz, MS; Brandon Santoni, PhD; Hassan R. Mir, MD*

9:08 am (p. 62) PAPER #4 — **Bridge Plating Ostosynthesis: Effect of Bridge Span on Interfragmentary Motion**
***Michael Bottlang**; Julia Henschel, MS; Stanley Tsai, MS; Daniel C. Fitzpatrick, MD; Steven M. Madey, MD*

9:14 am — Discussion

9:24 am — Refreshment Break

9:35 – 10:50 am

SYMPOSIUM 2: INFECTION-PREVENTION OF THE INFECTED FRACTURE: EVIDENCE BASED STRATEGIES FOR SUCCESS!

Moderators: *Emil H. Schemitsch, MD*
Cyril Mauffrey, MD, FACS, FRCS

9:35 am — **Introduction**
Emil H. Schemitsch, MD

9:40 am — **The Open Fracture: Are There Evidence Based Standards for Antiobiotic Therapy?**
David J. Hak, MD

9:50 am — **How I Debride a High Energy Open Fracture**
Michael T. Archdeacon, 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.

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Basic Science Focus Forum – WEDNESDAY, OCTOBER 11, 2017

10:00 am **The Induced Membrane Technique: How to Optimize Outcome**
Cyril Mauffrey, MD, FACS, FRCS

10:10 am **Management of Soft Tissue Defects: From Minor to Extreme**
Martin I. Boyer, MD

10:20 am **Beyond the Fracture: Can the Patient be Optimized?**
Michael D. McKee, MD

10:30 am **Adjunts to Prevent Infection: Is Anything Ready for Prime Time?**
Peter V. Giannoudis, MD, FACS, FRCS

10:40 am Discussion

10:50 – 11:24 am

PAPER SESSION 2: INFECTION

Moderators: *Emil H. Schemitsch, MD*
Cyril Mauffrey, MD, FACS, FRCS

10:50 am **Overview**
Emil H. Schemitsch, MD

10:55 am (p. 63) PAPER #5 **Immune Dysregulation in a Rat Model of Infected Femoral Segmental Bone Defect**
Hyunhee Ahn; ***Mara Schenker, MD****; Rishin J. Kadakia; Pallab Pradhan; Laura D. Weinstock; Levi B. Wood; Krishnendu Roy; Robert E. Guldberg; Nick J. Willett*

11:01 am (p. 64) PAPER #6 **Intrawound Vancomycin Powder Reduces *Staphylococcus aureus* Surgical Site Infections in a Rabbit Model**
James Paul Hovis, MD*; Robert V. O'Toole, MD; Theodore T. Manson, MD; Mark E. Shirtliff, PhD; Manjari Joshi, MD; Roman Natoli, MD*

11:07 am (p. 65) PAPER #7 **Intrawound Vancomycin Powder Reduces Bacterial Load in Contaminated Open Fracture Model**
Cyrus Theodore Caroom, MD*; Dustin Moore, MD; Nithya Mudaliar, MS; Craig Winkler, MD; Jefferson Jacob Murphree, MD; Ian Ratheal, MD; Michael Fry, BS; Jessica Tullar, PhD MPH; Abdul Hamood, PhD*

11:13 am (p. 66) PAPER #8 **Release of Vancomycin and Tobramycin from PMMA Cements Impregnated with Calcium Polyphosphate Hydrogel**
David C. Markel, MD*; Wei Song, PhD; Weiping Ren, PhD*

11:19 am Discussion

See pages 401 - 442 for financial disclosure information.

11:30 am-12:30 pm **INTERNATIONAL INDUSTRY LUNCH SYMPOSIUM**
West Ballroom CD **Zimmer Biomet**
(No CME credits offered)
Moderators: *Steven A. Olson, MD*
Peter V. Giannoudis, MD, FACS, FRCS

11:30 am **Augmented Fixation Advances in Trauma**
Faculty: *Thomas A. (Toney) Russell, MD*
John A. Scolaro, MD

West Ballroom CD
12:35 – 1:50 pm

SYMPOSIUM 3: JOINT SESSION WITH INTERNATIONAL SURGICAL GROUP- JOINT IMPACT INJURIES OF THE LOWER EXTREMITY

Moderators: *Peter V. Giannoudis, MD, FACS, FRCS*
Joseph Borrelli Jr., MD

12:35 pm **Introduction**
Peter V. Giannoudis, MD, FACS, FRCS

12:40 pm **The Basic Science/Molecular Make-up and Response to Compression of Articular Cartilage**
Joseph Borrelli Jr., MD

12:52 pm **The Role of Residual Articular Incongruity and Joint Instability in the Progression of PTOA?**
Steven A. Olson, MD

1:04 pm **Modulation of Cartilage's Response to Injury: Can Chondrocyte Apoptosis be Reversed?**
Peter V. Giannoudis, MD, FACS, FRCS

1:16 pm **Effectiveness of Cellular and Growth Factors for the Treatment of Injured Articular Cartilage**
Emil H. Schemitsch, MD

1:28 pm **Current Tissue Engineering Approaches to Regenerate Cartilage**
James P. Stannard, MD

1:40 pm Discussion

1:50 pm Break / Walk Back to BSFF Room *(West Meeting Room 109-110)*

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2:00 – 2:40 pm

PAPER SESSION 3: GENERAL TRAUMA

Moderators: *Peter V. Giannoudis, MD, FACS, FRCS*
Joseph Borrelli Jr., MD

2:00 pm **Overview**
Joseph Borrelli Jr., MD

2:05 pm (p. 67) PAPER #9 **Synovial Fluid Analysis Reveals a Novel Panel of Biomarkers Altered Following Articular Fracture**
***Steven A. Olson, MD**; Bridgette D. Furman; Janet Heubner, MS; Farsh Guilak, PhD; Yi-Ju Li, PhD; Kelly Kimmerling; Yi-Hung Wu, PhD; Virginia B. Kraus, MD, PhD*

2:11 pm (p. 68) PAPER #10 **Hemorrhagic Shock and Surgical Strategy (Nailing versus External Fixation) Affect the Microcirculation in Soft Tissues**
***Roman Pfeifer, MD**; Klemens Horst, MD; Zhi Qiao; Michel Teuben; Frank Hildebrand, MD; Hans-Christoph Pape, MD*

2:17 pm (p. 69) PAPER #11 **The Gut Microbiome: What Effect Does Our Diet Play in Fracture Healing?**
***Ashlee MacDonald, MD**; Christopher Farnsworth, PhD Student; Eric Schott, PhD Student; Alex Grier; Steven Gill, PhD; Hani Awad, PhD; Michael Zuscik, PhD; Robert Mooney, PhD; John P. Ketz, MD*

2:23 pm (p. 70) PAPER #12 **Can Intramuscular pH Levels Diagnose Acute Compartment Syndrome?**
***Christopher Doro, MD**; David Hennessy, MD; Robert V. O'Toole, MD; Thomas F. Higgins, MD*

2:29 pm Discussion

2:40 – 3:55 pm

SYMPOSIUM 4: TISSUE ENGINEERING–FACT OR FICTION?

Moderators: *Brett D. Crist, MD, FACS*
Mark Lee, MD

2:40 pm **Introduction**
Brett D. Crist, MD, FACS

2:45 pm **How to Make a Bone in 2017**
Mark Lee, MD

3:00 pm **Can We Get a Scaffold to Really Work?**
Kent Leach, PhD

3:15 pm **What are the Cartilage Options for Trauma Applications?**
Brett D. Crist, MD

3:30 pm **Have We Made Any Head Way in Soft Tissue Engineering?**
Kent Leach, PhD

3:45 pm Discussion

See pages 401 - 442 for financial disclosure information.

3:55 – 4:56 pm

PAPER SESSION 4: MANIPULATING HEALING

Moderators: *Brett D. Crist, MD, FACS*
Mark Lee, MD

3:55 pm — **Overview**
Mark Lee, MD

4:00 pm (p. 71) PAPER #13 — **Designer Chimeric Protein BV-265 Composite Matrix Demonstrates Efficacy in Nonhuman Primate Bone Repair Models at Substantially Lower Concentrations than BMP-2/Absorbable Collagen Sponge**
Howard Seeherman, PhD, VMD; *Stephen Berasi, PhD; Marc Bohner, PhD; Christopher Brown, PhD; Orly Grinberg, PhD; Pablo Morales, DVM; Eric Vanderploeg, PhD; Christopher Wilson, PhD; John M. Wozney, PhD*

4:06 pm (p. 72) PAPER #14 — **Adjunctive Immunomodulation Improves Efficacy of Autologous Minced Muscle Graft in a Porcine Model of Volumetric Muscle Loss**
Benjamin T. Corona, PhD; Jessica C. Rivera, MD; Joseph C. Wenke, PhD; ***Sarah M. Greising, PhD***

4:12 pm (p. 73) PAPER #15 — **Δ Effect of Cold Therapy on Bone Healing**
Daniel Castano, MD; *Jose Ramirez-GarciaLuna, MD, MsC; Geraldine Merle, PhD; Edward J. Harvey, MD, MsC*

4:18 pm — Discussion

4:28 pm (p. 74) PAPER #16 — **Hypoxic Preconditioning of Mesenchymal Stem Cell Spheroids Stimulates Segmental Bone Defect Repair**
Nasser Heyrani, MD; *Steve Shih-Yang Ho; Ben Pen Jui Hung, PhD; Mark Lee, MD; Jonathan Kent Leach, PhD*

4:34 pm (p. 75) PAPER #17 — **Δ Platelet-Rich Plasma as a Vehicle for Endothelial Progenitor Cell Delivery in Critical-Sized Bone Defects**
David Ramnaraign; *Charles Godbout, PhD; Brent Bates; Emil H. Schemitsch, MD; Aaron Nauth, MD*

4:40 pm (p. 76) PAPER #18 — **Δ Aminocaproic Acid Inhibits Periosteal Chondrogenesis and Promotes Periosteal Osteogenesis during Fracture Healing**
Dalibel M. Bravo, MD; *Anna Josephson, MS; Vivian Bradaschia Correa, PhD; Jason Huo, BS; Philipp Leucht, MD*

4:46 pm — Discussion

4:56 pm — Adjourn for the Day

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.

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ORTHOPAEDIC TRAUMA ASSOCIATION

2017 BASIC SCIENCE FOCUS FORUM

Thursday, October 12, 2017

(West Meeting Room 109-110)

6:00 am **Speaker Ready Room**
(West Meeting Room 103)

6:30 am **Registration**

Continental Breakfast
(West Meeting Room Lobby – Outside Meeting Room)

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

7:35 – 8:30 am **SYMPOSIUM 5: PATIENT OUTCOMES IN ORTHOPAEDICS- HOW TO EVALUATE IF YOUR TREATMENT IS REALLY WORKING**

Moderators: *Mohit Bhandari, MD, PhD, FRCSC*
Aaron Nauth, MD

7:35 am **Lower Extremity Outcomes in Trauma Patients**
Paul Tornetta III, MD

7:45 am **Upper Extremity Outcomes in Orthopaedic Trauma**
Peter Cole, MD

7:55 am **How Big of a Difference is Clinically Important? Using MCID in Orthopaedic Trauma**
Gerard Slobogean, MD

8:05 am **General Health Outcomes and Economic Analysis: How to Determine if the Cost Treatment is Worth It**
Samir Mehta, MD

8:15 am **The Impact of Psychosocial Factors on Outcomes in Orthopaedic Trauma**
William Obremskey, MD

8:25 am Discussion

See pages 401 - 442 for financial disclosure information.

8:30 – 9:27 am — PAPER SESSION 5: DOING IT BETTER

Moderators: *Mohit Bhandari, MD, PhD, FRCSC*
Aaron Nauth, MD

8:30 am — **Overview**
Aaron Nauth, MD

8:35 am
(p. 77)
PAPER #19 — **Negative Effects of Age-Related Chronic Inflammation on Skeletal Stem Cells**
Anna Josephson, MS; Vivian Bradaschia Correa, PhD; Shane Neibart, BS; ***Philipp Leucht, MD***

8:41 am
(p. 78)
PAPER #20 — **Effect of Nifedipine and Ketotifen on Joint Capsule Cell Based Collagen Gel Contraction**
Kristi Billard, BSc; Mei Zhang, MD; Prism S. Schneider, MD, PhD; Dave Hart, PhD; Paul T. Salo, MD; ***Kevin Hildebrand, MD, FRCSC***

8:47 am
(p. 79)
PAPER #21 — **Reduction in Angiogenic Support is the Primary Defect of Mesenchymal Stromal Cells Resident at the Site of Long Bone Non-Union**
Richard James Cuthbert*; Sarah M. Churchman; Penelope Castana, PhD; Hiang Boon Tan; Dennis McGonagle; Evangelia Papadimitriou, PhD; Elena Jones; Peter V. Giannoudis, MD*

8:53 am — Discussion

9:01 am
(p. 80)
PAPER #22 — **An Evaluation of Bone Marrow Aspirate Concentrate in Osteointegration of Fresh Osteochondral Allografts**
James P. Stannard, MD*; James Cook, PhD; Brett D. Crist, MD*

9:07 am
(p. 81)
PAPER #23 — **Femoral Neck Exposure for the Smith-Petersen Versus the Watson-Jones Approach**
Paul Lichstein, MD, MS; ***John P. Kleimeyer, MD****; Michael Githens, MD; John S. Vorhies, MD; Michael J. Gardner, MD; Michael J. Bellino; Julius A. Bishop, MD*

9:13 am
(p. 82)
PAPER #24 — **Δ The Effect of Smoking Cessation on Serum Biomarkers of Fracture Healing**
Justin Kleiner, BS; ***Joseph Johnson, MD****; Jeremy Truntzer; Scott McAllister; Matthew Edward Deren; Mursal Gardezi; Olivia Cummings; Melanie Ambler; Dioscaris Garcia; Christopher T. Born, MD*

9:19 am — Discussion

9:27 am — Refreshment Break

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.

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9:40 – 10:35 am

SYMPOSIUM 6: SCIENCE BEHIND PAIN MANAGEMENT

Moderators: *Todd O. McKinley, MD*
William T. Obremskey, MD

9:40 am **Overview**
Todd O. McKinley, MD

9:45 am **Current Epidemiology and Extent of Our Problems**
Hassan Mir, MD

9:55 am **Pain Control - Pharmacology and Different Mechanisms of Pain**
Anna Miller, MD

10:05 am **Clinical Management - Blocks, Multimodal, Medication Protocols and Contracts**
Joseph Hsu, MD

10:15 am **Health Policy - State, Federal, Insurer and Pharmacy Regulations**
A. Alex Jahangir, MD

10:25 am Discussion

10:35 – 11:05 am

PAPER SESSION 6: PAIN MANAGEMENT

Moderators: *Todd O. McKinley, MD*
William T. Obremskey, MD

10:35 am **Overview**
Todd O. McKinley, MD

10:40 am (p. 83) PAPER #25 **Reliability of Proxy-Reported PROMIS Physical Function and Pain Interference to Measure Outcomes in Elderly Patients Following Musculoskeletal Trauma**
***Maria Loreto Alvarez-Nebreda, MD, PhD**; Marilyn Heng, MD, MPh; Bernard Rosner, PhD; Michael F. McTague, MPH; Houman Javedan, MD; Mitchel B. Harris, MD; Michael John Weaver, MD*

10:46 am (p. 84) PAPER #26 **Overprescription of Opioids at Discharge in Patients After Fracture Surgery**
***Eric Chen, MD, PhD**; Lulu Li, BS; Paul Tornetta III, MD*

10:52 am (p. 85) PAPER #27 **Prescription Reporting with Immediate Medication Utilization Mapping (PRIMUM): Impact of an Alert on Controlled Substance Prescribing**
***Rachel Seymour, PhD**; Meghan Kusper Wally, MPH; Sharon Schiro, PhD; Joseph R. Hsu, MD; PRIMUM Group*

10:58 am Discussion

11:05 am **INDUSTRY LUNCH SYMPOSIA** *(On-site Registration Available)*
Boxed Lunch Included

See pages 401 - 442 for financial disclosure information.

ORTHOPAEDIC TRAUMA ASSOCIATION

2017 INTERNATIONAL TRAUMA CARE FORUM

October 11-12, 2017

(West Meeting Room 118-120)

International Committee

Peter V. Giannoudis, MD, FACS, FRCS, Chair
Ney Amaral, MD
Fernando de la Huerta, MD
Theodore Toan Le, MD
Amir M. Matityahu, MD
Cyril Mauffrey, MD, FACS, FRCS
Hans-Christoph Pape, MD, FACS
Sara M. Putnam, MD

Learning Objectives

Upon successful completion of this course, participants will be able to:

- Distinguish different methods of treating fracture and trauma complications from around the world
- Describe unique approaches to manage thromboprophylaxis of lower limb fractures between North America and UK
- Explain increased knowledge and understating of international clinical research
- Discuss different techniques of fracture reduction and managing complications of pelvic and acetabular reconstruction techniques
- Recognize and avoid complications when treating complex patella fractures
- Describe ways to manage avascular necrosis of talus
- Acquire knowledge on minimal invasive approaches to fixation of calcaneal fractures
- Explain the impact of joint impaction injuries to cartilage vitality and approaches to reverse the damage sustained.

The American Academy of Orthopaedic Surgeons designates this live activityfor a maximum of **10.50** ***AMA PRA Category 1 Credits***™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

ORTHOPAEDIC TRAUMA ASSOCIATION

2017 INTERNATIONAL TRAUMA CARE FORUM

Wednesday, October 11, 2017

(West Meeting Room 118-120)

6:00 am **Speaker Ready Room**
(West Meeting Room 103)

6:30 am **Registration**

Continental Breakfast
(West Meeting Room Lobby – Outside Meeting Room)

7:30 am **Welcome**
Peter V. Giannoudis, MD, FACS, FRCS, Program Chair

7:35 – 8:15 am **SYMPOSIUM 1: SURGICAL TECHNIQUES: HOW I DO IT**

Moderators: *Cyril Mauffrey, MD, FACS, FRCS*
Tim Chesser, FRCS

7:35 am **Overview**
Cyril Mauffrey, MD, FACS, FRCS

7:37 am **Spino-Pelvic Injuries**
Enrique Guerado, MD, PhD

7:47 am **Acetabulum Articular Impaction**
Peter V. Giannoudis, MD, FACS, FRCS

7:57 am **Pipkin Fracture**
Amir M. Matityahu, MD

8:07 am Discussion

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

See pages 401 - 442 for financial disclosure information.

8:15 – 8:47 am

PAPER SESSION 1: PELVIS/ACETABULUM

Moderators: *Christopher G. Moran, MD, FRCS*
Fernando De La Huerta, MD

8:15 am (p. 87) PAPER #28
Hemorrhage Control and Transfusion Requirements of Pelvic Ring Fractures Attending a Major Trauma Centre for Emergency and Definitive Care: Does Early Aggressive Resuscitation Influence Mortality at 1 Year?
James Bassett, MBBS; *David Slattery, MBBS; Greg Pickering, MBBS; Anthony Ward, MBBS; Mehool R. Acharya; Tim Chesser, MBBS*

8:21 am (p. 88) PAPER #29
Native Hip Survival and Long-Term Patient-Reported Outcomes following Acetabular Fracture
Chloe E.H. Scott, MD, MSc; *Timothy O. White, MD; Stuart Goudie; John Annan, MBBS; Deborah MacDonald, BSc; John F. Keating, MD*

8:27 am (p. 89) PAPER #30
Reduced Survival for Uncemented Compared to Cemented Total Hip Arthroplasty after Failed Open Reduction and Internal Fixation for Acetabular Fractures
John Clarke-Jenssen, MD; *Marianne Westberg, PhD; Olav Roise, PhD, MD; Tone Bere, PhD; Stein A. Ovre, PhD, MD; Ingunn Silberg, MD; Jan Erik Madsen*

8:33 am (p. 90) PAPER #31
Navigated Screw Osteosynthesis for Pelvic Fractures Using A Hybrid-Operating Room
Peter H. Richter, MD; *Florian T. Gebhard, MD; Konrad Schuetze, MD*

8:39 am Discussion

8:44 – 9:00 am

SIGN SCHOLAR PRESENTATIONS

8:44 am
The Impact of the SIGN Pelvic Fracture Care Program in the Southern Philippines Medical Center
Kristoffer Roland U. Roa, MD

8:52 am
Treatment of the Intra-Articular and Extra-Articular Distal Femoral Fractures Using SIGN Nail at Kumi Orthopaedic Center in Uganda
John Ekure, MD

9:00 – 9:40 am

PAPER SESSION 2: BEST OF THE BEST

Moderators: *William M. Ricci, MD*
Thomas A. (Toney) Russell, MD
Ian Winson, MD

9:00 am (p. 91) PAPER #32
An Algorithm Can Predict Blood Product Transfusion Requirements in First 24 Hours and 30-day Survival After Pelvic Fracture: 5-year Series of 589 Patients
Pierre Hubert Michael Pechon, MBBS*; Luke Rothwell, MBBS; John Hardman, MBBS; Angus Lewis, MBBS; Jasvinder Daurka, MBBS*

9:06 am (p. 92) PAPER #33
Managing Soft Tissues in Severe Lower Limb Trauma in an Aging Population
Tim Noblet; Phillipa Jackson; Patrick Foster, MBBS; Martin Taylor, MBBS; Paul J. Harwood, MBBS; ***Jay Wiper***

9:12 am (p. 93) PAPER #34
3D-Printed Titanium Cages Combined with Masquelet Technique for Reconstruction of Bone Defects
Kevin Dorland Tetsworth, MD, FRACS*; Vaida Glatt, PhD*

9:18 am (p. 94) PAPER #35
Management and Outcomes of the Treatment of Intracapsular Neck of Femur Fractures in Young Patients
Michalis Panteli, MD*; Ippokratis Pountos; Anthony Howard; Peter V. Giannoudis, MD*

9:24 am (p. 95) PAPER #36
Risk Factors for Fibular Nail Failure in the Management of Unstable Fractures of the Ankle Joint
Tom Henry Carter, MBBS*; Katrina Roxanne Bell, MBBS; Samuel Peter Mackenzie, MBBS; Marcus A. Hollyer, BSc; Emma Chelsea Gill, BSc; Andrew David Duckworth, MD, PhD; Timothy O. White, MD*

9:30 am Discussion

9:40 am Refreshment Break

See pages 401 - 442 for financial disclosure information.

SYMPOSIUM 2: GUEST NATION (UNITED KINGDOM)

9:50 – 10:40 am

Thromboprophylaxis an Update of Current Practice: Can We Reach a Consensus?

Moderators: *William M. Ricci, MD*
Keith Willett, MD, FRCS

9:50 am **Overview**
William M. Ricci, MD

9:55 am **Thromboprophylaxis after Pelvic/Acetabulum Fractures**
David C. Teague, MD

10:05 am **Thromboprophylaxis after Hip Fractures**
Henry Broekhuyse, MD

10:15 am **Thromboprophylaxis after Knee Fractures**
John F. Keating, FRCSEd

10:25 am **Thromboprophylaxis after Ankle/Foot Fractures**
Timothy O. White, MD, FRCS

10:35 am Discussion

PAPER SESSION 3: FOOT AND ANKLE

10:40 – 11:12 am

Moderators: *Victor A. de Ridder, MD, PhD*
Hans-Christoph Pape, MD, FACS

10:40 am
(p. 96)
PAPER #37
Channel-Assisted Minimally Invasive Repair of Acute Achilles Tendon Rupture
Hua Chen, MD, PhD*; Peifu Tang, MD*

10:46 am
(p. 97)
PAPER #38
Clinical and Functional Outcome following Distal Tibial Fracture Treated by Circular External Fixation
Vasileios Giannoudis; Emma Ewins; Patrick Foster, MBBS; Martin Taylor, MBBS; ***Paul J. Harwood, MBBS***

10:52 am
(p. 98)
PAPER #39
Medial Malleolus Fixation in Combination with Fibular Intramedullary Nailing: Are We Wasting our Time?
Tom Henry Carter, MBBS*; Samuel Peter Mackenzie, MBBS; Katrina Roxanne Bell, MBBS; Emma Chelsea Gill, BSc; Marcus A. Hollyer, BSc; Andrew David Duckworth, MD, PhD; Timothy O. White, MD*

10:58 am (p. 99) PAPER #40 **Clinical and Radiographic Outcomes of Talar Fractures**
Paul H.C. Stirling, MBBS; *Samuel Peter Mackenzie, MBBS; Robbie Ray; Nicholas David Clement, MBBS; Conor McCann; John F. Keating, MD*

11:04 am Discussion

SPECIAL INTEREST LECTURE
Minimal Invasive Approaches to Calcaneal Fractures: What Have We Learned?
11:12 – 11:25 am ***Ian Winson, MD***

11:30 am-12:30 pm *West Ballroom CD* **INTERNATIONAL INDUSTRY LUNCH SYMPOSIUM**
Zimmer Biomet
(No CME credits offered)
Moderators: *Steven A. Olson, MD*
Peter V. Giannoudis, MD, FACS, FRCS

11:30 am **Augmented Fixation Advances in Trauma**
Faculty: *Thomas A. (Toney) Russell, MD*
John A. Scolaro, MD

West Ballroom CD
SYMPOSIUM
12:35 – 1:50 pm
JOINT SESSION WITH BASIC SCIENCE FOCUS FORUM-JOINT IMPACT INJURIES OF THE LOWER EXTREMITY

Moderators: *Peter V. Giannoudis, MD, FACS, FRCS*
Joseph Borrelli Jr., MD

12:35 pm **Overview**
Peter V. Giannoudis, MD, FACS, FRCS

12:40 pm **The Basic Science/Molecular Make-up and Response to Compression of Articular Cartilage**
Joseph Borrelli Jr., MD

12:52 pm **The Role of Residual Articular Incongruity and Joint Instability in the Progression of PTOA?**
Steven A. Olson, MD

1:04 pm **Modulation of Cartilage's Response to Injury: Can Chondrocyte Apoptosis be Reversed?**
Peter V. Giannoudis, MD, FACS, FRCS

1:16 pm **Effectiveness of Cellular and Growth Factors for the Treatment of Injured Articular Cartilage**
Emil H. Schemitsch, MD

See pages 401 - 442 for financial disclosure information.

1:28 pm **Current Tissue Engineering Approaches to Regenerate Cartilage**
James P. Stannard, MD

1:36 pm Discussion

1:50 pm Break / Walk Back to ITCF Room *(West Meeting Room 118-120)*

2:00 – 2:48 pm PAPER SESSION 4: FEMORAL FRACTURES

Moderators: *Paul Duffy, MD*
Andrew David Duckworth, BSc, MSc, FRCSEd

2:00 pm (p. 100) PAPER #41 **Δ Validity of Utilizing the RUST Scoring System in Radiographic Evaluation of Femoral Shaft Fractures**
***Devin J. Conway, Doctoral Student**; Billy Thomson Haonga, MD; Edmund Eliezer, MD; Saam Morshed, MD, PhD; David Shearer, MD, MPH*

2:06 pm (p. 101) PAPER #42 **Consolidation in Femoral Fractures: A Cohort Study in Patients Exposed and Not Exposed to Bisphosphonates**
***Jorge D. Barla, MD**; Francisco Jose Nally, MD; Guido Sebastian Carabelli, MD; Carlos F. Sancineto, MD*

2:12 pm (p. 102) PAPER #43 **Healing of Atypical Subtrochanteric Femur Fractures after Cephalomedullary Nailing: Which Factors Predict Union?**
***Jae-Woo Cho, MD**; Chang-Wug Oh, MD, PhD; Frankie Leung, MD, PhD; Kichul Park, MD; Merng Koon Wong; Ernest Kwek, MD; Jong-Keon Oh, MD, PhD; Beom Soo Kim, MD*

2:18 pm Discussion

2:24 pm (p. 103) PAPER #44 **Δ Does the Choice of Antegrade or Retrograde Approach to Intramedullary Nailing of Diaphyseal Femur Fractures Affect Progression of Knee Range of Motion in Settings that Lack Formal Physiotherapy?**
***Devin J. Conway, Doctoral Student**; Billy Thomson Haonga, MD; Edmund Eliezer, MD; Saam Morshed, MD, PhD; David Shearer, MD, MPH*

2:30 pm (p. 104) PAPER #45 **Management and Outcomes of Periprosthetic Fractures of the Femur**
***Gunasekaran Kumar, MD, FRCS**; Amy Berger, MS*

2:36 pm (p. 105) PAPER #46 **Intramedullary Nailing for Atypical Femoral Fracture with Excessive Anterolateral Bowing**
***Young-Chang Park, MD**; Hyung Keun Song; Xuan Zheng; Kyu-Hyun Yang*

2:42 pm Discussion

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.

2:48 – 3:13 pm

SYMPOSIUM 3: PATELLA FRACTURES– MY PREFERRED METHOD OF TREATMENT

Moderators: *David J. Hak, MD*
Sushrut Babhulkar, MS ORTH, MCh ORTH

2:48 pm **Comminuted Patella Fractures**
Daniel S. Horwitz, MD

2:58 pm **Periprosthetic Patella Fractures**
Nigel T. Rossiter, FRCSEd

3:08 pm Discussion

3:13 – 3:33 pm

KEYNOTE LECTURE
Universal Care in Trauma: The International Perspective
Keith Willett, MD, FRCS

Moderators: *William M. Ricci, MD*
Peter V. Giannoudis, MD, FACS, FRCS

3:33 pm Refreshment Break

3:43 – 4:30 pm

PAPER SESSION 5: HIP FRACTURES

Moderators: *Christian Krettek, MD, FRACS*
Brent L. Norris, MD

3:43 pm
(p. 106)
PAPER #47
Evolution of a Combined Orthopaedic/ Orthogeriatric Hip Fracture Service in a District Hospital: Key Lessons Learned
Sandeep Deo, MD*, Kareem Elsorafy, MBBS*

3:49 pm
(p. 107)
PAPER #48
Δ Marked Deterioration in Living Status and Use of Aids After Operative Management of Hip Fractures in the Elderly
Emil H. Schemitsch, MD*; Sheila Sprague, PhD; Martin J. Heetveld; Sofia Bzovsky, BSc; Diane Heels-Ansdell, BSc; Qi Zhou; Marc F. Swiontkowski, MD; Mohit Bhandari, MD; FAITH Investigators*

3:55 pm
(p. 108)
PAPER #49
Analysis of Intertrochanteric Hip Fractures Failure: What Do Trauma Surgeons Agree Upon?
Yoram A. Weil*; Mariano Agustín Codesido; Rami Mosheiff; Meir Liebergall; Amal Khoury*

4:01 pm Discussion

Δ OTA Grant

See pages 401 - 442 for financial disclosure information.

4:06 pm
(p. 109)
PAPER #50

Early Clinical Experience with the SIGN Hip Construct
Justin Roth, DO; Brian Goldman, DO; John Schlechter, DO; Lewis G. Zirkle Jr, MD; ***David Shearer, MD, MPH***

4:12 pm
(p. 110)
PAPER #51

Use of Fully Threaded Cannulated Screws Decreases Femoral Neck Shortening after Fixation of Femoral Neck Fractures
Yoram A. Weil, MD*; Rami Mosheiff; Amal Khoury; Meir Liebergall*

4:18 pm
(p. 111)
PAPER #52

Unstable Intertrochanteric Fractures -Is the Best Plate a Nail?
Adam Tucker, MBBS*; Kevin Donnelly, MBBS; Sinead McDonald; Andrew Foster*

4:24 pm

Discussion

4:45 pm-6:30 pm

INTERNATIONAL RECEPTION/INTERNATIONAL POSTERS
International Orthopaedic Trauma Association (IOTA) Charter Signing
Ocean Foyer Level 1

See pages 401 - 442 for financial disclosure information.

ORTHOPAEDIC TRAUMA ASSOCIATION

2017 INTERNATIONAL TRAUMA CARE FORUM

Thursday, October 12, 2017

(West Meeting Room 118-120)

6:00 am **Speaker Ready Room**
(West Meeting Room 103)

6:30 am **Registration**

Continental Breakfast
(West Meeting Room Lobby – Outside Meeting Room)

7:25 am **Welcome**
Peter V. Giannoudis, MD, FACS, FRCS, Program Chair

7:30 – 8:10 am **SYMPOSIUM 4: (PELVIC /ACETABULAR NON UNIONS): HOW I DO IT**

Moderators: *Pierre Guy, MD*
Christoph Josten, MD

7:30 am **Sacral Non–Union**
Hans-Christoph Pape, MD, FACS

7:40 am **Pelvic Non–Union**
Christian Krettek, MD, FRACS

7:50 am **Acetabular Non–Union**
Tim Chesser, FRCS

8:00 am Discussion

8:10 – 8:35 am **PAPER SESSION 6: UPPER EXTREMITY**

Moderators: *Steven A. Olson, MD*
Takashi Mashusita, MD

8:10 am
(p. 112)
PAPER #53 **Long-Term Patient Satisfaction and Residual Symptoms After Plate Fixation and Nonoperative Treatment for Displaced Midshaft Clavicular Fractures**
Sarah Woltz, MD*; Pieta Krijnen, PhD; Inger B. Schipper, MD, PhD*

See pages 401 - 442 for financial disclosure information.

8:16 am (p. 113) PAPER #54 **Proximal Humerus Reintervention After Open Reduction and Internal Fixation for Fracture: A Survivorship Analysis and Report on Patient Outcomes**
Jason Strelzow, MD; *Paul H.C. Stirling, MBBS; C. M. Robinson*

8:22 am (p. 114) PAPER #55 **Long-term Follow Up after Implantation of a Bipolar Radial Head Prosthesis Versus Osteosynthesis to Treat Complex Radial Head Fractures: A Matched Pair Retrospective Study**
David Steimer, MD; *Martin Panzica; Christian Krettek, MD, FRACS*

8:28 am Discussion

8:35 – 9:00 am

PAPER SESSION 7: GENERAL TRAUMA TOPICS

Moderators: *Nikolaos K. Kanakaris, MD, PhD*
Bertil Bouillon, MD, PhD

8:35 am (p. 115) PAPER #56 **Long-Term Results and Quality of Life After Thoracoscopic Anterior Stabilization for Thoracolumbar Fractures in Patients without Spinal Cord Injury**
Arjen Johannes Smits, MD; *Arwin Noor; Fred C. Bakker, MD, PhD; Jaap Deunk, MD, PhD[1]; Frank Willem Bloemers*

8:41 am (p. 116) PAPER #57 **Δ Osseointegrated Implants for Transfemoral Amputees: Radiographic Evaluation of Bone Remodeling**
Kevin Tetsworth, MD, FRACS; *Jiao Jiao Li, PhD; William Lu, PhD; Munjed Al Muderis, MD*

8:47 am (p. 117) PAPER #58 **Inappropriate Weight Bearing After Surgical Treatment of the Lower Extremity Does Not Influence the Number and Severity of Complications**
Alexander Maximilian Eickhoff, MD; *Carina Fiedler; Raffael Cintean, MD; Florian T. Gebhard, MD*

8:53 am Discussion

9:00 – 9:40 am

SYMPOSIUM 5: AVASCULAR NECROSIS OF TALUS: BIOLOGICAL BASED THERAPIES? FUSION OR REPLACEMENT?

Moderators: *Theodore Miclau III, MD*
Florian T. Gebhard, MD, PhD

9:00 am **Biological Based Therapy**
Edward J. Harvey, MD

9:10 am **Fusion**
Roy Sanders, MD

9:20 am **Replacement**
Richard E. Buckley, 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.

9:30 am Discussion

9:40 am Refreshment Break

9:53 – 10:25 PAPER SESSION 8: LOWER LIMB RECONSTRUCTION

Moderators: *Yan Wang, MD*
Ross K. Leighton, MD

9:53 am (p. 118) PAPER #59
The Results of Membrane-Induced Osteogenesis in Posttraumatic Bone Defects
***Jin-Kak Kim, MD**; Jae-Woo Cho, MD; Do-Hyun Yeo, MD; Gi-Ho Moon, MD; Beom-Soo Kim, MD; Jong-Keon Oh, MD, PhD; Won-Seok Choi, MD*

9:59 am (p. 119) PAPER #60
The Treatment of Complex Pediatric and Adolescent Tibial Fractures with The Ilizarov Method
***Juergen Messner, MD**; Louise Johnson, Clinical Psychologist; Namal Perera, MBBS; Paul J. Harwood, MBBS; Martin Taylor, MBBS; Simon Britten, MBBS; Patrick Foster, MBBS*

10:05 am (p. 120) PAPER #61
Functional Outcome of Intra-Articular Tibial Plateau Fractures: The Impact of Posterior Column Fractures
Juriaan Van Den Berg; Maike Reul, MD; Menno Nunes Cardozo; Anastasiya Starovoyt; Eric Geusens; Stefaan Nijs, MD, PhD; ***Harm Hoekstra, MD, PhD***

10:11 am (p. 121) PAPER #62
Clinical Outcomes of Combined Fixation Strategy Using a Mini Plate in Complex Patellar Fracture
***Jae-Woo Cho, MD**; Jin-Kak Kim, MD; Beom-Soo Kim, MD; Do-Hyun Yeo, MD; Gi-Ho Moon, MD; Jong-Keon Oh, MD, PhD*

10:17 am Discussion

10:25 – 11:00 am SYMPOSIUM 6: MY WORST CASE: WHEN THINGS GO WRONG, THEN WHAT?

Moderators: *Theodore Miclau III, MD*
Florian T. Gebhard, MD, PhD

10:25 am **Overview**
Malcolm Smith, MD

10:30 am *Hans–Christoph Pape, MD, FACS*

10:45 am *Kodi Kojima, MD*

11:00 am **INDUSTRY LUNCH SYMPOSIA** *(On-site Registration Available)*
Boxed Lunch Included

See pages 401 - 442 for financial disclosure information.

ORTHOPAEDIC TRAUMA ASSOCIATION

2017 ANNUAL MEETING

Thursday, October 12, 2017

(West Ballroom AB)

6:00 am **Speaker Ready Room**
(West Meeting Room 103)

6:30 am **Registration**

11:00 am **INDUSTRY LUNCH SYMPOSIA** *(On-site Registration Available)*
Boxed Lunch Included

1:00 pm **Welcome and Donor Awards**
Michael D. McKee, MD, Program Committee Chair

Kelly A. Lefaivre, MD, Peter J. O'Brien, MD and Pierre Guy, MD
Local Hosts

West Ballroom AB
1:20 – 2:50 pm

SYMPOSIUM 1: HOT OFF THE PRESS - HOW EVIDENCED BASED MEDICINE HAS CHANGED FRACTURE TREATMENT IN 2017

Moderator: *Niloofar Dehghan, MD*

Open Fractures: Which Type of Fluid and Pressure is Best?
Ross K. Leighton, MD

Distal Clavicle Fractures: Should We Fix Them?
Jeremy Alan Hall, MD

AC Joint Injuries: When to Fix and When to Treat with a Sling?
Michael D. McKee, MD

Treatment of the Ulnar Nerve after Distal Humerus Fractures: Transpose or Leave in Situ?
Emil H. Schemitsch, MD

Non-operative Treatment of Olecranon Fractures in Elderly: It is Possible!
Andrew D. Duckworth, MD, PhD

Hip Fracture ORIF: Cannulated Screws or DHS?
Michael Blankstein, MD

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.

Don't Be Afraid to Allow Early Weight Bearing After Ankle and Tibia Fracture Fixation!
Niloofar Dehghan, MD

Syndesmotic Ankle Injuries: When Do You Remove the Screws? Should We Use Tightrope Instead?
David W. Sanders, MD

Questions

2:50 pm — Refreshment Break (Exhibit hall opens at 2:30)
Visit Scientific Posters & Technical Exhibits
(West Exhibit Hall B)

West Ballroom AB

3:20 – 4:29 pm

SCIENTIFIC PAPER SESSION 1: PROGRAM HIGHLIGHTS

Moderators - Michael D. McKee, MD & Michael J. Gardner, MD

3:20 pm (p. 125) PAPER #63 — **Δ Improved Reduction of the Tibiofibular Syndesmosis with Tightrope Compared to Screw Fixation: Results of a Randomized Controlled Study**
(COTS) Canadian Orthopaedic Trauma Society; ***David W. Sanders, MD****; Prism S. Schneider, MD, PhD; Christina Tieszer, BSc, MSc; Abdel–Rahman Lawendy, MD; Michel Taylor, MD*

3:26 pm (p. 126) PAPER #64 — **Fixation of Distal Tibia Fractures (UK FixDT): A Randomized Controlled Trial of Locking Plate Fixation versus Intramedullary Nail Fixation in the Treatment of Adult Patients with a Displaced Fracture of the Distal Tibia**
Matthew L. Costa, PhD

3:32 pm (p. 127) PAPER #65 — **UK Wound Management of Open Lower Limb Fractures (UK WOLLF): A Randomized Control Trial of Standard Wound Management versus Negative Pressure Would Therapy in the Treatment of Adult Patients with an Open Wound Fracture of the Lower Limb**
Matthew L. Costa, PhD; ***Miguel Fernandez, MBBS***

3:38 pm — Discussion

3:43 pm (p. 128) PAPER #66 — **Δ Operative versus Nonoperative Treatment of Acute Displaced Distal Clavicle Fractures: A Multicenter Randomized Controlled Trial**
(COTS) Canadian Orthopaedic Trauma Society; ***Jeremy Alan Hall, MD****; Niloofar Dehghan, MD; Emil H. Schemitsch, MD; Aaron Nauth, MD; Robert Korley, MDCM; Robert G. McCormack, MD; Pierre Guy, MD; Steven Ray Papp, MD; Michael D. McKee, MD*

Δ OTA Grant

See pages 401 - 442 for financial disclosure information.

3:49 pm (p. 129) PAPER #67
Does Motion at 8 Weeks Predict Nonunion in Nonoperatively Managed Humeral Shaft Fractures? A Prospective Multicenter Evaluation
Paul Tornetta, III, MD; *Lisa K. Cannada, MD; Robert A. Hymes, MD; Clifford B. Jones, MD; Brian H. Mullis, MD; Eben Carroll, MD; William Obremskey, MD; Andrew J. Marcantonio, DO; David C. Teague, MD; Robert F. Ostrum, MD; Michael Charles Tucker, MD; Dirk William Kiner, MD; Lauren Germany; Michael Del Core, MD; Sarah Dawson; Heidi Israel, PhD*

3:55 pm (p. 130) PAPER #68
Multicenter Retrospectice Analysis of Humeral Shaft Fractures: Are Sarmiento's Results Widely Reproducible?
Rafael Serrano, MD; *Hassan R. Mir, MD; H. Claude Sagi, MD; Daniel S. Horwitz, MD; John E. Tidwell, MD; John P. Ketz, MD; Brian J. Kistler, MD; Jonathan H. Quade, MD; Michael J. Beebe, MD; Anjan R. Shah, MD*

4:01 pm (p. 131) PAPER #69
The FaB (Fractures and Bisphosphonates) Trial: A Multicenter, Double-Blind, Randomized Controlled Trial on the Effect of Alendronic Acid on Healing and Clinical Outcomes of Wrist Fractures
Andrew D. Duckworth, MD, PhD; *Christopher E. Tuck, BSc; Aryelly Rodriguez, MSc; Gordon D. Murray, PhD; Stuart H. Ralston, MD*

4:07 pm Discussion

4:12 pm (p. 132) PAPER #70
Costs and Complications of Single-Stage Fixation Versus 2-Stage Treatment of Select Bicondylar Tibial Plateau Fractures
Walter W. Virkus, MD; *Jesse Caballero, BS; Laurence B. Kempton, MD; Matthew Cavallero, MD; Rich Rosales, BS; Todd O. McKinley, MD; Greg E. Gaski, MD*

4:18 pm (p. 133) PAPER #71
Locking Plate Fixation of Bicondylar Tibial Plateau Fractures Raises Treatment Costs Without Clinical Benefit
Matthew Cavallero, MD; Rich Rosales, BS; Jesse Caballero, BS; Walter W. Virkus, MD; Laurence B. Kempton, MD; Todd O. McKinley, MD; ***Greg E. Gaski, MD***

4:24 pm Discussion

West Ballroom AB

4:30 – 5:10 pm

SESSION OF GENERAL INTEREST:
"Building Strong Public Health Care: The Dangers of Monopoly and Bureaucracy"
Brian Day, MD
Honorary Associate Professor in Orthopaedics, University of British Columbia
President, Cambie Surgeries Corporation

5:10 pm-6:10 pm OTA BUSINESS MEETING
(Members Only) *(General Session Room - West Ballroom AB)*

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 12, 2017

5:10 pm-6:10 pm **HAPPY HOUR (in the Exhibit Hall)**
(West Exhibit Hall B)
(All Meeting Attendees Invited)

6:10 pm-8:10 pm **WELCOME RECEPTION**
(West Ballroom CD)
Join your colleagues for cocktails and hors d'oeuvres while enjoying breathtaking floor to ceiling views of the mountains and harbor.

See pages 401 - 442 for financial disclosure information.

ORTHOPAEDIC TRAUMA ASSOCIATION

2017 ANNUAL MEETING

Friday, October 13, 2017

(West Ballroom AB)

6:00 am	**Speaker Ready Room** *(West Meeting Room 103)*
6:30 am	**Registration**
6:30 am - 7:30 am	**Concurrent Breakout Sessions –** Seating available first come, first-served. Case Presentations and Mini Symposium
6:30 am	**Continental Breakfast** *(Outside Breakout Session Rooms)*

6:30 – 7:30 am — **MINI SYMPOSIA AND CASE PRESENTATIONS** — ***No Tickets Required***

Complex Biocondylar Tibial Plateau Fractures *(West Meeting Room 109)*
Case Presentations
Moderator: *John Scolaro, MD*
Faculty: *Timothy Achor, MD; David Barei, MD; Samir Mehta, MD* and *Gilbert Ortega, MD*

Registries: What Can We Learn from Them? *(West Meeting Room 110)*
Mini Symposium
Moderator: *Pierre Guy, MD*
Faculty: *Matthew Costa, FRCS, PhD; Brad Petrisor, MD; Cecilia Rogmark, MD* and *Boris Sobolev, MD*

Expedited Hip Fracture Management *(West Meeting Room 111 & 112)*
Mini Symposium
Moderator: *Kyle Judd, MD, MS*
Faculty: *Damien Billow, MD; John T. Gorczyca, MD; Daniel Mendelson, MD; Christina Seifert, MD; Gillian Soles, MD* and *Michael Willey, MD*

Managing Complications in Fracture Surgery: A Trauma Surgeon's Guide Mini Symposium *(West Meeting Room 114 & 115)*
Moderator: *Emil H. Schemitsch, MD*
Faculty: *Nilooofar Dehghan, MD; Michael D. McKee, MD; Theodore Manson, MD; Aaron Nauth, MD* and *Benjamin Potter, 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.

FRIDAY, OCTOBER 13, 2017

Pelvis and Acetabulum Fractures *(West Ballroom AB)*
Case Presentations
Moderator: *Paul Tornetta III, MD*
Faculty: *Reza Firoozabadi, MD; David C. Templeman, MD; Joshua Layne Gary, MD* and *Cory A. Collinge, MD*

7:00 am **Scientific Posters, Technical Exhibits & Continental Breakfast**
(West Exhibit Hall B)

7:45 am - 9:30 am **Concurrent Sessions**
(General Session, Skills Labs, Mini Symposia and Case Presentations run concurrently.)
Scientific Paper Session 2: Foot and Ankle (7:45 am - 9:29 am)
Skills Labs (8:00 am - 9:00 am)
Mini-Symposia and Case Presentations (8:00 am - 9:30 am)

West Ballroom AB
7:45 – 9:29 am

SCIENTIFIC PAPER SESSION 2: FOOT and ANKLE

Moderators - Brett D. Crist, MD & John D. Adams, MD

7:45 am (p. 134) PAPER #72
Single Screw Fixation Compared with Double Screw Fixation for Treatment of Medial Malleolar Fractures: A Prospective Randomized Trial
Richard E. Buckley, MD FRCPC; *Ernest Kwek, MD; Paul Duffy, MD; Robert Korley, MDCM; Emilia Rydberg Moller, MD; Andrew S.R. Buckley; Prism S. Schneider, MD, PhD*

7:51 am (p. 135) PAPER #73
Weight Bearing or Non-Weight Bearing After Surgical Treatment of Ankle Fractures: The WOW! Study. A Multicenter Randomized Controlled Trial
Diederik Pieter Johan Smeeing, MD; *Roderick Marijn Houwert; Jan P. Briet; Koen Lansink, MD, PhD; Loek Leenen, MD, PhD; Peer Van der Zwaal; Stephan W.A.M. Van Zuthpen; Bas Twigt; Jochem M. Hoogendoorn; Egbert Verleisdonk; Michiel J.M. Segers; Falco Hietbrink*

7:57 am (p. 136) PAPER #74
The AIM Trial Extended Follow–up: Three-year Outcomes from an Equivalence Randomized Clinical Trial Comparing Close Contact Casting with Internal Fixation Surgery for Unstable Malleolar Fractures in Patients Over 60 Years
Keith Willett, MBBS; *David Keene, PhD; Robert Handley, MB, BS; Tim Chesser, MBBS; Ian Pallister, MD; Dipesh Mistry, PhD; Susan Wagland, PhD; Scott Parsons, Ranjit Lall; Sallie Lamb, PhD*

8:03 am Discussion

8:08 am (p. 137) PAPER #75
An Immediate Weight-Bearing Protocol for the Determination of Ankle Stability in Patients with Isolated Distal Fibular Fractures
Eric Bonness, MD; ***Justin C. Siebler, MD***; *Lori K. Reed, MD; Matthew A. Mormino, MD*

See pages 401 - 442 for financial disclosure information.

8:14 am (p. 138) PAPER #76
Rate of Syndesmotic Instability Following Anatomic Posterior Malleolar Fracture Open Reduction and Internal Fixation
Matthew A. Miller, MD; Clay Spitler, MD; Matt L. Graves, MD; William Replogle, PhD; Josie M. Hydrick, BS; LaRita C. Jones, PhD; ***Patrick F. Bergin, MD***

8:20 am (p. 139) PAPER #77
Evaluation of a Custom Energy-Storing Lower Limb Carbon Fiber Orthosis
Benjamin Kyle Potter, MD*; Kevin M. Kuhn, MD; John Fergason; Joseph R. Hsu, MD; Wade Gordon, MD; Johnny Owens; Jessica C. Rivera, MD; Robert Sheu, MD; Daniel J. Stinner, MD; Jason Wilken, PhD; Michael Bosse, MD; Jennifer DeSanto, RN, MPH; Daniel Scharfstein, PhD; Yanjie Huang, MS; Ellen MacKenzie, PhD; METRC PRIORITI-MTF Team*

8:26 am
Discussion

8:31 am (p. 140) PAPER #78
Limb Salvage and Amputation Outcomes Following Severe Distal Tibia and Hindfoot Injuries
Michael Bosse, MD*; Lisa Reider, PhD; Joshua Gary, MD; Wade Gordon, MD; Daniel Scharfstein, PhD; Saam Morshed, MD, PhD; Eben Carroll, MD; Reza Firoozabadi, MD; Jason Luly, MS; Clifford Jones, MD; Ellen MacKenzie, PhD; METRC OUTLET Team*

8:37 am (p. 141) PAPER #79
Calcaneal Avulsion Fractures in 35 Consecutive Patients Treated Over 17 Years at a Level I Trauma Center: An Injury Pattern Fraught with Soft-Tissue and Bony Complications
Phillip M. Mitchell, MD*; David O'Neill, BA; Cory A. Collinge, MD*

8:43 am (p. 142) PAPER #80
Syndesmotic Disruption in Tibial Plafond Fractures: What Are The Risk Factors for Missing the Diagnosis?
Justin Haller, MD*; Michael Githens, MD; David L. Rothberg, MD; Thomas F. Higgins, MD; David P. Barei, MD; Sean E. Nork, MD*

8:49 am
Discussion

8:54 am (p. 143) PAPER #81
Computerized Adaptive Testing in Ankle Fracture Surgery
Elizabeth Gausden, MD*; Benedict U. Nwachukwu, MD; Ashley Levack, MD; Danielle Sin, MS; David Stephenson Wellman, MD; Dean G. Lorich, MD*

9:00 am (p. 144) PAPER #82
Measuring Outcomes Over Time in Tibial Plafond Fractures: A Comparison of Generic, Musculoskeletal-Specific, and Foot and Ankle-Specific Outcome Measures
Aresh Sepehri, MD*; Kelly A. Lefaivre, MD; Peter J. O'Brien, MD; Henry Broekhuyse, MD; Abdullah Mamun; Pierre Guy, MD*

9:06 am (p. 145) PAPER #83
Prophylaxis of Venous Thromboembolism in Patients with a Nonsurgical Fracture of the Lower Extremity Immobilized in a Below–Knee Plaster Cast: A Randomized Controlled Trial
Marlieke Bruntink, MD*; Yannick Groutars; Roelf Breederveld, MD, PhD; Wim Tuinebreijer; Robert Jan Derksen MD, PhD*

9:12 am (p. 146) PAPER #84
Determinants of Functional Outcomes following Ankle Fracture
Megan Audet, BA*; Chang–Yeon Kim, MD; Heather Vallier, MD*

FRIDAY, OCTOBER 13, 2017

9:18 am
(p. 147)
PAPER #85

Posterior Malleolar Fracture Morphology Determines Outcome in Rotational Type Ankle Fractures: A Prospective Clinical Trial
***Robin Blom, PhD Candidate**; Diederik Tim Meijer, MD; Robert-Jan Oene De Muinck Keizer, MD, PhD; Inger Sierevelt, MSc; Tim Schepers, MD, PhD; Sjoerd Stufkens, MD, PhD; Gino Kerkhoffs, MD, PhD; J. Carel Goslings, MD, PhD; Job N. Doornberg, MD, PhD*

9:24 am — Discussion

9:30 am — Refreshment Break
Visit Scientific Posters & Technical Exhibits
(West Exhibit Hall B)

8:00 am - 9:30 am — **Concurrent Breakout Sessions**
(Skills Labs, Mini Symposia and Case Presentations run concurrently.)
Skills Labs (8:00 am - 9:00 am)
Mini-Symposia and Case Presentations (8:00 am - 9:30 am)

8:00 – 9:00 am — **SKILLS LABS** — ***ARRIVE EARLY– Labs Fill Quickly!***

Distal Femur Plating *(West Meeting Room 119 & 120)*
Lab Leader: *Gerard P. Slobogean, MD*
Faculty: *Greg Gaski, MD; Jennifer Hagen, MD* and *Jason Nascone, MD*

SIGN Fracture Care International *(West Meeting Room 118)*
Lab Leader: *Lewis G. Zirkle Jr., MD*
Faculty: *John Ekure, MD; Kristoffer Roa, MD; Carla Smith, MD* and *Paul Whiting, MD*

Pilon Fracture Plating *(West Meeting Room 121 & 122)*
Lab Leader: *John Scolaro, MD*
Faculty: *David Barei, MD; James Learned, MD; Edward Westrick, MD* and *Brad Yoo, MD*

See pages 401 - 442 for financial disclosure information.

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

Management of Scapular Fractures Mini Symposium *(West Meeting Room 109)*
Moderator: *William T. Obremskey, MD*
Faculty: *Clifford B. Jones, MD; Paul Tornetta III, MD* and *Peter Cole, MD*

An Outcomes-Based Approach to Distal Radius Fracture Management Mini Symposium *(West Meeting Room 110)*
Moderator: *Raymond Pensy, MD*
Faculty: *John Capo, MD; Asif Ilyas, MD* and *David Ring, MD*

Mental Health in Orthopaedic Trauma– Patients and Providers Mini Symposium *(West Meeting Room 111 & 112)*
Moderator: *Anna N. Miller, MD*
Faculty: *Joseph Hsu, MD; Hassan Mir, MD; Jeffrey M. Smith, MD* and *Heather Vallier, MD*

Periprosthetic Femur Fractures Case Presentations *(West Meeting Room 114 & 115)*
Moderator: *John T. Gorczyca, MD*
Faculty: *Catherine Humphrey, MD; Matthew Jimenez, MD* and *Kyle Judd, MD*

Multi-Center Trials in Orthopaedic Trauma: Lessons Learned Mini Symposium *(West Meeting Room 116 & 117)*
Moderator: *Gregory J. Della Rocca, MD, PhD, FACS*
Faculty: *Mohit Bhandari, MD; Richard E. Buckley, MD, FRCPC Robert V. O'Toole, MD* and *Emil H. Schemitsch, MD*

Distal Humerus Fractures: Tips and Tricks Case Presentations *(West Meeting Room 208 & 209)*
Moderator: *Utku Kandemir, MD*
Faculty: *Milan Sen, MD; Michael J. Gardner, MD; Michael D. McKee, MD* and *Bertrand Perey, MD*

9:30 am Refreshment Break
Visit Scientific Posters & Technical Exhibits
(West Exhibit Hall B)

The OTA is honored to welcome United Kingdom as the 2017 Guest Nation. We are pleased to have the opportunity for collaboration with these colleagues, and a chance to recognize their contributions and achievements.

(General Session Room - West Ballroom AB)

10:00 – 11:30 am

SYMPOSIUM 2: CHANGING THE SYSTEM: CAN WE IMPROVE TRAUMA CARE? EXPERIENCE FROM THE GUEST NATION

Moderator: *Tim Chesser, MBBS*

Introduction
John F. Keating, MD

Comparisons and Differences of Health Care Systems and Trauma Care Between UK and North America
Keith Willett, MBBS

Can We Improve The Outcome of Major Trauma Patients with a Trauma Network?
Christopher G. Moran, MD

Hip Fractures - Does Standardisation and Audit Make a Difference?
Tim Chesser, MBBS

Open Fractures - Centralisation of Care, What We Have Learned
Michael Kelly, MBBS

Establishing a Multicentre Trauma Research Network - Early Results
Matthew L. Costa, PhD

Questions

See pages 401 - 442 for financial disclosure information.

11:30 am – 12:00 pm

JOHN BORDER, MD MEMORIAL LECTURER

(General Session Room - West Ballroom AB)

Roy Sanders, MD
Chairman, University of South Florida
Department of Orthopedics
President, Florida Orthopaedic Institute
Chief, Orthopaedics, Tampa General
Editor-in-Chief, Journal of Orthopaedic Trauma
Temple Terrace, Florida, USA

"Observations in Innovation"

Introduction: William M. Ricci, MD, OTA President

12:10 pm - 1:10 pm — Lunch and
Visit Scientific Posters & Technical Exhibits
(West Exhibit Hall B)

12:10 pm – 1:10 pm — ORTHOPAEDIC TRAUMA ASSOCIATION

New Member Luncheon
(tickets required)
(West Meeting Room 306)

12:10 pm – 1:10 pm

Women in Orthopaedic Trauma
Kathy Cramer, MD Memorial Luncheon
(tickets required)
(West Meeting Room 301)

Chair: *Carla Smith, MD*

12:25 pm – 1:10 pm — **LUNCHTIME GUIDED POSTER AND VIDEO TOURS** — ***Tickets Required***

(PT1) **Foot/Ankle** *(West Exhibit Hall B)*
Guide: *Paul Tornetta III, MD*

(PT2) **Knee/Tibia** *(West Exhibit Hall B)*
Guide: *Stephen A. Kottmeier, MD*

(VT) **Video Tours** *(West Exhibit Hall B)*
Guide: *Robert Ostrum, 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.

FRIDAY, OCTOBER 13, 2017

1:15 pm - 2:45 pm **Concurrent Sessions**
(General Session, Skills Labs, Mini Symposia and Case Presentations run concurrently.)
Scientific Paper Session 3: Pelvis and Acetabulum (1:15 pm - 2:24 pm)
Skills Labs (1:15 pm - 2:15 pm)
Mini-Symposia and Case Presentations (1:15 pm - 2:45 pm)

West Ballroom AB
1:15 – 2:24 pm

SCIENTIFIC PAPER SESSION 3: PELVIS and ACETABULUM

Moderators - David W. Sanders, MD & David J. Stephen, MD

1:15 pm (p. 148) PAPER #86
Assessing Quality of Reduction After Acetabular Fracture Surgery: Importance of Gap Versus Step Displacement
Diederik Verbeek, MD*; Jelle van der List, MD; Camden Michael Tissue, MD; David L. Helfet, MD*

1:21 pm (p. 149) PAPER #87
Acetabular Fractures with a Posterior Dislocation
Jamie Nicholson; ***John F. Keating, MD****; Issaq Ahmed, MD*

1:27 pm (p. 150) PAPER #88
The Longitudinal Short, Medium, and Long-Term Functional Recovery After Unstable Pelvic Ring Injuries
Michael E. Neufeld, MD*; Kelly A. Lefaivre, MD; Peter J. O'Brien, MD; Pierre Guy, MD; Abdullah Mamun; Henry Broekhuyse, MD*

1:33 pm Discussion

1:38 pm (p. 151) PAPER #89
Preperitoneal Pelvic Packing for Acute Hemorrhage Control Is Not Associated with an Increased Risk of Infection After Anterior Pelvic Ring Fixation
Philip F. Stahel, MD*; Clay Cothren Burlew, MD; Corey Henderson, MS; Fredric Pieracci, MD; Ernest E. Moore, MD*

1:44 pm (p. 152) PAPER #90
Contrast Blush on CT Is a Poor Predictor of Active Bleeding on Pelvic Angiography
Andrew S. Do, BS*; Benjamin Childs, BS; Sarah L. Gael, MD; Heather A. Vallier, MD*

1:50 pm (p. 153) PAPER #91
Does Reduction Technique for Pelvic and Acetabular Injuries Affect Trauma-Induced Coagulopathy? A Prospective Cohort Study
Zackary O. Byrd, MD*; Elizabeth Davis, MD; Prism S. Schneider, MD, PhD; Anabel Acuna, BS; April Vanderslice; Bryan A. Cotton, MD MPh; Milton L. Routt, MD; Joshua Gary, MD*

1:56 pm Discussion

2:01 pm (p. 154) PAPER #92
Percutaneous Transiliac-Transsacral Fixation of Sacral Insufficiency Fractures Improves Ambulation and Rate of Disposition to Home
J. Brock Walker, MD*; Sean Mitchell, MD; Sean Karr, MD; Jason Lowe; Clifford Jones, MD*

See pages 401 - 442 for financial disclosure information.

2:07 pm (p. 155) PAPER #93 — **Fixation Strategy Using Sequential Intraoperative Examination Under Anesthesia for Unstable Lateral Compression Pelvic Ring Injuries Reliably Predicts Union with Minimal Displacement**
Frank R. Avilucea, MD; *Michael T. Archdeacon, MD; Cory A. Collinge, MD; Marcus F. Sciadini, MD; H. Claude Sagi, MD; Hassan R. Mir, MD*

2:13 pm (p. 156) PAPER #94 — **Unstable Pelvic Ring Fixation: How Soon Can Patients Safely Bear Weight?**
Lucas S. Marchand; *Zachary Mark Working, MD; Ajinkya Rane, MD; Abby Howenstein, MD; Iain Elliott, MD; Justin Haller, MD; David L. Rothberg, MD; Thomas F. Higgins, MD*

2:19 pm — Discussion

1:15 pm -2:45 pm — **Concurrent Breakout Sessions**
(Skills Labs, Mini Symposia and Case Presentations run concurrently.)
Skills Labs (1:15 pm - 2:15 pm)
Mini-Symposia and Case Presentations (1:15 pm - 2:45 pm)

1:15 – 2:15 pm **SKILLS LABS** *ARRIVE EARLY– Labs Fill Quickly!*

Distal Humerus Plating *(West Meeting Room 118)*
Lab Leader: *Lisa K. Cannada, MD*
Faculty: *Chad Corrigan, MD; Niloofar Dehghan, MD; Edward Harvey, MD; Michael D. McKee, MD* and *Emil H Schemitsch, MD*

Ankle Spanning External Fixation *(West Meeting Room 119 & 120)*
Lab Leader: *Julius A. Bishop, MD*
Faculty: *William Wood Cross, MD; John Scolaro, MD* and *Michael Weaver, MD*

IM Nailing of Proximal Tibial Fractures *(West Meeting Room 121 & 122)*
Lab Leader: *Paul Tornetta III, MD*
Faculty: *Reza Firoozabadi, MD; Daniel Horwitz, MD; Samir Mehta, MD; Hassan Mir, MD; William M. Ricci, MD* and *Judith Siegel, MD*

1:15 – 2:45 pm MINI SYMPOSIA AND CASE PRESENTATIONS

No Tickets Required

The Coming Bundle Mini Symposium *(West Meeting Room 109)*
Moderator: *Kenneth A. Egol, MD*
Faculty: *Joseph Bosco, MD; Roy Davidovitch, MD; A. Alex Jahangir, MD* and *Sanjit Konda, MD*

Compartment Syndrome: What You Need to Know to Stay Out of Trouble Mini Symposium *(West Meeting Room 110)*
Moderator: *Cyril Mauffrey, MD, FACS, FRCS*
Faculty: *Peter Giannoudis, MD, FACS, FRCS; David J. Hak, MD; Mark Hake, MD* and *Andrew Schmidt, MD*

Controversies in Patient Safety and Ethics Mini Symposium *(West Meeting Room 111 & 112)*
Moderator: *Douglas W. Lundy, MD*
Faculty: *Michael T. Archdeacon, MD; John Campbell, MD; Samir Mehta, MD; Douglas Roger, MD, JD; Jeffrey M. Smith, MD; Wade R. Smith, MD; Philip Stahel, MD; Todd Swenning, MD* and *Nirmal Tejwani, MD*

How to Use Ring Fixators (TSF and Ilizarov) for Tibia Fractures Mini Symposium *(West Meeting Room 114 & 115)*
Moderator: *Theodore Manson, MD*
Faculty: *Joseph Hsu, MD; Kevin Tetsworth, MD* and *Stephen Quinnan, MD*

Complex Elbow Fracture Dislocations Mini Symposium *(West Meeting Room 116 & 117)*
Moderator: *William T. Obremskey, MD*
Faculty: *Lisa K. Cannada, MD; Chad Corrigan, MD; Niloofar Dehghan, MD; Michael D. McKee, MD* and *Emil H. Schemitsch, MD*

Pearls and Pitfalls in ORIF of Proximal Humerus Fractures Case Presentations *(West Meeting Room 208 & 209)*
Moderator: *Utku Kandemir, MD*
Faculty: *Michael J. Gardner, MD; John T. Gorczyca, MD; Michael D. McKee, MD* and *Milan Sen, MD*

2:24 – 3:16 pm SCIENTIFIC PAPER SESSION 4: UPPER EXTREMITY

West Ballroom AB

Moderators - Gregory J. Della Rocca, MD, PhD, FACS & David C. Ring, MD, PhD

2:24 pm (p. 157) PAPER #95 **Comparison of PROMIS to Legacy Patient-Reported Outcome Scores in Upper Extremity Trauma**
Elizabeth Gausden, MD; *Danielle Sin, MS; Ashley Levack, MD; Andrew Nellestein, MS; Peter D. Fabricant, MD; David Stephenson Wellman, MD; Dean G. Lorich, MD*

See pages 401 - 442 for financial disclosure information.

2:30 pm (p. 158) PAPER #96
Randomized, Placebo-Controlled Clinical Trial Evaluating Ketotifen Fumarate in Reduction of Posttraumatic Elbow Joint Contracture
Prism S. Schneider, MD, PhD; *Nicholas Mohtadi, MD, MSc; Tolulope Sajobi; Meng Wang; Neil White; Alexandra Garven, BSc; Kevin Hildebrand, MD, FRCSC*

2:36 pm (p. 159) PAPER #97
Radial Nerve Injury and Recovery After Humeral Nonunion Surgery
Paul Tornetta, III, MD; ***Justin Koh, MD****; Clifford B. Jones, MD; J. Brock Walker, MD; Andrew Sems, MD; Sharul Saxena; Henry Aidoo Boateng, MD; Kathleen Ringenbach, PhD; Clay Spitler, MD; Hassan R. Mir, MD; Shaan Patel; Reza Firoozabadi, MD; Kate Bellevue, MD; Daniel S. Horwitz, MD; Lisa K. Cannada, MD; Michael Bosse, MD; J. Stewart Buck, MD; Jerald Westberg, BA; Andrew H. Schmidt, MD; Laurence B. Kempton, MD; Andrew J. Marcantonio, DO; Peter Carl Krause, MD; Matthew Delarosa, MD; Tayseer Shamaa, MD; Brian H. Mullis, MD; Andrew Gudeman; Ross K. Leighton, MD; Amro Alhoukail, MD; Saam Morshed, MD, PhD; Abigail Cortez, BA; David W. Sanders, MD; Christina Tieszer, BSc*

2:42 pm
Discussion

2:47 pm (p. 160) PAPER #98
Minimally Displaced, Isolated Radial Head Fractures Do Not Require Formal Physical Therapy: Results of a Prospective Randomized Trial
Jack Haglin, BS*; Ariana Lott, BA; Rebekah Belayneh, BA; David N. Kugelman, BS; Abdullah M. Qatu, BS; Sanjit R. Konda; Kenneth A. Egol, MD*

2:53 pm (p. 161) PAPER #99
The Influence of Shortening on Clinical Outcome in Healed, Displaced, Midshaft Clavicle Fractures After Nonoperative Treatment
Ewan B. Goudie, MD*; Nicholas D. Clement, MBBS; Iain R. Murray, PhD; C. M. Robinson, FRCS*

2:59 pm (p. 162) PAPER #100
Proximal Humeral Fracture Fixation Using the PH Cage: A Retrospective Study of 125 Patients to a Minimum of 6 Months Post Treatment
Eric W. Fulkerson, MD*; Paul Paterson, MD*

3:05 pm (p. 163) PAPER #101
Reliability, Validity, Responsiveness, and Minimal Important Change of the Disabilities of the Arm, Shoulder and Hand and Constant-Murley Scores in Patients with a Humeral Shaft Fracture
Kiran C. Mahabier, MD; ***Dennis Den Hartog, MD, PhD****; Nina Theyskens; Michael Verhofstad, MD, PhD; Esther Van Lieshout, MSc; On behalf of HUMMER Investigators*

3:11 pm
Discussion

3:16 pm
Refreshment Break
Visit Scientific Posters & Technical Exhibits
(West Exhibit Hall B)
Exhibit hall open 3:00 pm–6:15 pm

3:45 pm -5:30 pm
Concurrent Breakout Sessions
(Mini Symposia and General Session run concurrently.)
Mini-Symposia (3:45 pm - 5:15 pm)
Scientific Paper Session 5: Wrist, Hand, Tibia and Pediatric (3:46 pm - 5:30 pm)

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.

3:45 – 5:15 pm | **MINI SYMPOSIA** | *No Tickets Required*

What to Do with the Front: Anterior Pelvic Ring Management *(West Meeting Room 109)*
Moderator: *John Scolaro, MD*
Faculty: *Jonathan Eastman, MD; Reza Firoozabadi, MD; Geoffrey Marecek, MD; Milton Routt, MD; Rahul Vaidya, MD* and *Raymond Wright, MD*

The Blasted Distal Femur Fracture: How to Improve Outcomes *(West Meeting Room 110)*
Moderator: *Lisa K. Cannada, MD*
Faculty: *Cory Collinge, MD; Robert Hymes, MD; Kyle Jeray, MD; Thomas Jones, MD* and *Erik Kubiak, MD*

Developing and Maintaining a Successful Clinical Research Program *(West Meeting Room 111 & 112)*
Moderator: *Heather Vallier, MD*
Faculty: *Mary Breslin, BA; Julie Agel, ATC* and *William T. Obremskey, MD*

Orthopaedic Trauma Coding *(West Meeting Room 114 & 115)*
Moderator: *Paul T. Appleton, MD*
Faculty: *J. Scott Broderick, MD; William R. Creevy, MD; Brett D. Crist, MD* and *M. Bradford Henley, MD*

The Smooth Hip Fracture Admission– Top 15 in Best Evidence to Avoid Complications *(West Meeting Room 116 & 117)*
Moderator: *Pierre Guy, MD*
Faculty: *Stephen Kates, MD; Eric Meinberg, MD* and *Daniel Mendelson, MD*

West Ballroom AB

3:46 – 5:30 pm

SCIENTIFIC PAPER SESSION 5: WRIST, HAND, TIBIA and PEDIATRIC

Moderators - David J. Hak, MD & Cyril Mauffrey, MD, FACS, FRCS

3:46 pm (p. 164) PAPER #102
Volar Plate Fixation Versus Plaster in Extra-Articular Distal Radius Fractures: A Prospective Multicenter Randomized Controlled Trial
Marjolein A.M. Mulders, MD*; Monique M.J. Walenkamp, MD, PhD; J. Carel Goslings, MD PhD; Niels W.L. Schep, MD, PhD*

3:52 pm (p. 165) PAPER #103
The Efficacy of Mini C-Arm Fluoroscopy for the Closed Reduction of Distal Radius Fractures in Adults: A Randomized Controlled Trial
Steven Kyle Dailey, MD*; Ashley R. Miller, MD; Rafael Kakazu, MD; John D. Wyrick, MD; Peter J. Stern, MD*

See pages 401 - 442 for financial disclosure information.

3:58 pm (p. 166) PAPER #104
Δ Vehicle Steering Errors and Reaction Time Following Distal Radius Fracture Surgical Fixation
Lyle T. Jackson, MD; *Michael Koerner, MD; Stephanie Lewis Tanner; Rebecca G. Snider; Jennifer McKay, OT[1]; Johnell O. Brooks, PhD[2]; Kyle J. Jeray, MD*

4:04 pm (p. 167) PAPER #105
Effectiveness of Postoperative Analgesic Immobilization in Patients with Distal Radius Fracture Treated with Volar Locking Plating: A Prospective, Randomized Clinical Trial
Fernando Brandao Andrade-Silva, MD, PhD; *Joao Pedro Rocha, MD; Adriana Carvalho, BSc; Kodi Edson Kojima; Jorge Santos Silva, MD, PhD*

4:10 pm (p. 168) PAPER #106
A Prospective Randomized Controlled Trial Comparing Open Reduction and Internal Fixation, Non-Spanning External Fixation, and Closed Reduction with Percutaneous Fixation for Dorsally Displaced Distal Radius Fractures
Stephane Bergeron, MD, MPH; Rudolf Reindl, MD; Edward J. Harvey, MD, MSc; Hans J. Kreder, MD; Elham Rahme, PhD; ***Gregory K. Berry, MD****; Canadian Orthopaedic Trauma Society*

4:16 pm Discussion

4:21 pm (p. 169) PAPER #107
Role of the Fibula in Predicting Tibial Nonunions After Intramedullary Nailing
Robert D. Wojahn, MD; *Amanda Spraggs-Hughes; Michael J. Gardner, MD; William M. Ricci, MD; Christopher M. McAndrew, MD, MS*

4:27 pm (p. 170) PAPER #108
Incidence of Rotational Malalignment After Intramedullary Nailing of Tibial Fractures: Efficacy of Low-Dose Protocolled Bilateral Postoperative CT Assessment
Nils Jan Bleeker, MSc; *Job N. Doornberg, MD, PhD; Ruurd Jaarsma, MD, PhD; Megan Cain, MD, BsC; Kaj T.A. Lambers, MD*

4:33 pm (p. 171) PAPER #109
Suprapatellar Versus Infrapatellar Approach to Intramedullary Nailing of Tibia Fractures: An Objective Measure of Knee Cartilage
Derek J. Donegan, MD; *Kevin D'Aquilla, BS; Thomas Rose; Annamarie D. Horan, PhD; Patrick J. Hesketh, BS; Ravinder Reddy, PhD; Samir Mehta, MD*

4:39 pm Discussion

4:44 pm (p. 172) PAPER #110
Is Continuous Near-Infrared Spectroscopy (NIRS) Reliable to Monitor Development of Compartment Syndrome in Patients with Lower Leg Injuries?
Andrew H. Schmidt, MD; *Michael Bosse, MD; Robert V. O'Toole, MD; William Obremskey, MD; Vadim Zipunnikov, PhD; Junrui Di, PhD Candidate; Katherine Frey, MPH; Ellen MacKenzie, PhD; The Major Extremity Trauma Research Consortium*

4:50 pm (p. 173) PAPER #111
Does Early Administration of Antibiotics After Open Tibia Fractures Really Decrease Infection Rates?
Steven F. Shannon; *Daniel Mascarenhas, BS; Manjari Joshi, MD; Daniel Connelly, BA/BS; Robert V. O'Toole, MD*

4:56 pm Discussion

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.

FRIDAY, OCTOBER 13, 2017

5:01 pm
(p. 174)
PAPER #112

Best Trauma Paper at the 2017 POSNA Annual Meeting
"Acceptable Reduction" for Supracondylar Humerus Fractures in Children
Unni Narayanan, MBBS; ***William Wood, MD***

5:07 pm
(p. 175)
PAPER #113

Single Versus Both Bone Fixation: A Retrospective Review of 10 Years of Pediatric Forearm Fractures
Ashley Miller, MD*; Tyler Keller; Kevin Little, MD*

5:13 pm
(p. 176)
PAPER #114

The Utility of Intraoperative Arthrogram in the Management of Pediatric Lateral Condyle Fractures of the Humerus
John S. Vorhies, MD*; Shawn Funk, MD; Marilyn Elliott, BS; Anthony Ian Riccio, MD; Brandon Ramo, MD*

5:19 pm
(p. 177)
PAPER #115

Is Less More? Assessing the Value of Early Clinical and Radiographic Follow-Up for Operative Supracondylar Humerus Fractures
Rachel Mednick Thompson, MD*; Elizabeth Hubbard, MD; Marilyn Elliott, BS; Anthony Ian Riccio, MD; Daniel Sucato, MD, MS*

5:25 pm Discussion

West Meeting Room 211
4:30 – 6:00 pm

SPEED MENTORING
Co-Chairs: ***Lisa K. Cannada, MD***
Michael T. Archdeacon, MD

Faculty: *Daniel J. Coll, PA-C; James R. Ficke, MD; Mitchel B. Harris, MD; Douglas W. Lundy, MD; Samir Mehta, MD; Theodore Miclau III, MD; Robert F. Ostrum, MD; Nigel D. Rossiter, FRCSEd; Scott Smith, MD; Nirmal C. Tejwani, MD* and *Ryan E. Will, MD*

5:30 pm-6:30 pm

Military Reception
(Level 1 Ocean Foyer)
All Active Duty Military, Retired Military, and Landstuhl Distinguished Visiting Scholar participants are welcome to attend.

5:35 – 6:20 pm

SUDS N' SCIENCE GUIDED POSTER AND VIDEO TOURS

Tickets Required

(PT3) **Upper Extremity** *(West Exhibit Hall B)*
Guide: *Michael D. McKee, MD*

(PT4) **General Interest** *(West Exhibit Hall B)*
Guide: *Michael J. Gardner, MD*

(VT) **Video Tours** *(West Exhibit Hall B)*
Guide: *Raphael Neiman, MD*

See pages 401 - 442 for financial disclosure information.

ORTHOPAEDIC TRAUMA ASSOCIATION

2017 ANNUAL MEETING

Saturday, October 14, 2017

(West Ballroom AB)

6:00 am	**Speaker Ready Room** *(West Meeting Room 103)*
6:30 am	**Registration**
6:30 am - 7:30 am	**Concurrent Breakout Sessions –** Seating available first come, first-served. Case Presentations and Mini Symposium
6:30 am	**Continental Breakfast** *(Outside Breakout Session Rooms)*

6:30 – 7:30 am — **MINI SYMPOSIA AND CASE PRESENTATIONS** — ***No Tickets Required***

Management of Distal Tibia Fractures: Pearls and Pitfalls Mini Symposium *(West Meeting Room 109)*
Moderator: *Derek Donegan, MD*
Faculty: *Frank Liporace, MD; Stephen Quinnan, MD; John Scolaro, MD* and *Heather Vallier, MD*

Stay Out of Trouble in Operative Pediatric Fractures Mini Symposium *(West Meeting Room 110)*
Moderator: *Steven Gibbons, MD*
Faculty: *Amr Abdelgawad, MD; Ahmed Thabet Hagag, MD* and *Enes Kanlic, MD*

Challenges in Intertrochanteric Hip Fractures Mini Symposium *(West Meeting Room 111 & 112)*
Moderator: *Theodore Manson, MD*
Faculty: *Eben Carroll, MD* and *Cyril Mauffrey, MD, FACS, FRCS*

Soft Tissue Management of the Mangled Upper and Lower Extremity Mini Symposium *(West Meeting Room 114 & 115)*
Moderator: *Raymond Pensy, MD*
Faculty: *John Ingari, MD; Asif Ilyas, MD* and *Daniel A. Osei, MD*

Pelvic Ring Disruption Case Controversies: Diagnosis and Treatment Case Presentations *(West Meeting Room 116 & 117)*
Moderator: *Jason Nascone, MD*
Faculty: *Pierre Guy, MD; Robert V. O'Toole, MD; H. Claude Sagi, MD* and *Adam Starr, 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.

SATURDAY, OCTOBER 14, 2017

7:00 am **Scientific Posters, Technical Exhibits & Continental Breakfast**
(West Exhibit Hall B)

West Ballroom AB

7:30 – 9:00 am

SYMPOSIUM 3: MANAGING INFECTION IN ORTHOPAEDIC TRAUMA: REACHING CONSENSUS AND THE ROLE OF EMERGING TECHNOLOGIES

Moderators: *Robert V. O'Toole, MD*
Emil H. Schemitsch MD

Introduction
Emil H. Schemitsch, MD

The Infected Fracture: Can We Agree on Standard Definitions?
Cyril Mauffrey, MD, FACS, FRCS

Diagnosing Infection in Orthopaedic Trauma: We Have a Problem!
Robert V. O'Toole, MD

Infection Diagnosis, Treatment, and Prevention Technologies on the Horizon
Mark E. Shirtliff, PhD

Hardware Considerations: When and How to Remove or Revise the Fixation!
Paul Tornetta III, MD

Acute and Chronic Infection: Is There a Gold Standard for Management of the Wound and Bone Defect?
Peter V. Giannoudis, MD, FACS, FRCS

Question, Answer and Case Discussion

9:00 am - 10:38 am **Concurrent Sessions**
(General Session and Mini Symposia run concurrently.)
Scientific Paper Session 6: Polytrauma and Post Traumatic Reconstruction (9:00 am - 10:38 am)
Mini-Symposia (9:00 am - 10:30 am)

West Ballroom AB

9:00 – 10:38 am

SCIENTIFIC PAPER SESSION 6: POLYTRAUMA AND POST TRAUMATIC RECONSTRUCTION

Moderators - Brett D. Crist, MD & Michael D. McKee, MD

9:00 am
(p. 178)
PAPER #116 **Incidence of Complications and Mortality in Polytrauma Patients Managed Either with ETC or DCO: Lessons Learned**
Siddharth R. Shah, MBBS*; Michael McArdle; Peter V. Giannoudis, MD, FACS, FRCS*

See pages 401 - 442 for financial disclosure information.

9:06 am (p. 179) PAPER #117
Extremity Trauma Results in Severe Coagulopathy and Impaired Fibrinolysis Based on Serial Rapid Thrombelastography
Prism S. Schneider, MD, PhD; *Ioannis N. Liras; Ellie Rahbar, PhD; Mark L. Prasarn; Joshua Gary, MD; Bryan A. Cotton, MD, MPH*

9:12 am (p. 180) PAPER #118
The Early Immunologic Response in Multiply Injured Patients with Orthopaedic Injuries Is Associated with Organ Dysfunction
Greg Edward Gaski, MD; *Cameron Metzger, BS; Robert Wessel, MD; Jeremy Adler, BS; Tyler McCarroll, BS; Andrew Cutshall, BS; Yoram Vodovotz, PhD; Timothy R. Billiar; Todd O. McKinley, MD*

9:18 am Discussion

9:23 am (p. 181) PAPER #119
Significant Reduction of Pulmonary Embolism in Orthopaedic Trauma Patients
Adam J. Starr, MD; ***Zachary Shirley, MD***; *Michael Cripps, MD; Patrick Sutphin, MD, PhD; Gene Hu, BS; Drew T. Sanders, MD; Brigham Au, MD; Ashoke K. Sathy, MD; Aaron Gebrelul, MD; Alexander Eastman, MD*

9:29 am (p. 182) PAPER #120
Limitations in Upper-Extremity Weight-Bearing Increase Length of Stay in Polytraumatized Patients
Ida Leah Gitajn, MD; *Nicole Krum, OT; Nathan N. O'Hara; Gerard P. Slobogean, MD; Robert V. O'Toole, MD; Raymond A. Pensy, MD*

9:35 am (p. 183) PAPER #121
Extra-Articular Malunions and Nonunions of the Scapula: A Comparison of Functional Outcome Before and After Reconstruction
Joseph Denis Schirmers, MD; Jeff Gilbertson; Lisa K. Schroder; Joscelyn Tatro; ***Peter A. Cole, MD***

9:41 am Discussion

9:46 am (p. 184) PAPER #122
Timing of Definitive Fixation with Respect to Flap Coverage in Open Tibia Fractures
Paul Tornetta, III, MD; ***Casey Kuripla, MD***; *Justin Koh, MD; Andrew Sems, MD; Tayseer Shamaa; Hassan R. Mir, MD; Benjamin D. Streufert; Clay Spitler, MD; Heather A. Vallier, MD; Debi Sorg; Brian H. Mullis, MD; Brian McGowan; John C. Weinlein, MD; Lisa K. Cannada, MD; Jonathan Charlu; Jerald Westberg, BA; Emily Wagstrom; Saam Morshed, MD, PhD; Abigail Cortez, BA; Peter C. Krause, MD; Andrew J. Marcantonio, DO; Gillian Soles, MD; Jason Lipof, MD*

9:52 am (p. 185) PAPER #123
Rates of Surgical Site Infection After Open Fractures: Findings of the UK Wound Management of Open Lower Limb Fractures (WOLLF) Trial
James Masters, MB, BS; *Julie Bruce, PhD; Nick Parsons; Matthew L. Costa, PhD*

9:58 am (p. 186) PAPER #124
Impact of Management on Reoperation Rates in Gustillo-Anderson Grade III Open Fractures of the Lower Limb
Pieter V. Vermaak; *Luke Parsons; Fergus Liggins; Miguel Fernandez, MBBS; Joseph T. Hardwicke; Jayne Ward, MBBS*

10:04 am Discussion

SATURDAY, OCTOBER 14, 2017

10:09 am (p. 187) PAPER #125
NURD 2.0: Prediction of Tibial Nonunion at Any Time Within 3 Months of Injury
Robert V. O'Toole, MD; *Josef Jolissaint, BS; Kevin O'Halloran, MD; Anthony R. Carlini, MS; Keir Ross, BS; Justin Fowler, MD; Renan C. Castillo, PhD*

10:15 am (p. 188) PAPER #126
Delay in Flap Coverage for Open Tibia Fractures Increases Inpatient Complications: A Cohort Study of 140 North American Trauma Centers Improvement Program
Daniel Pincus, MD; *James Byrne, MD; Avery Nathens; Anna N. Miller, MD; Philip R. Wolinsky, MD; David Wasserstein, MD; Bheeshma Ravi; Steven Borland; Richard John Jenkinson, MD*

10:21 am (p. 189) PAPER #127
Treatment of Bone Defects in Open Tibia Fractures Treated with an IMN
William Obremskey, MD; *Paul Tornetta, III, MD; Saam Morshed, MD, PhD; Robert V. O'Toole, MD; Joseph R. Hsu, MD; Ellen MacKenzie, PhD; Katherine Frey, MPH; Michael Bosse, MD; Jason Luly, MS; Major Extremity Trauma Research Consortium*

10:27 am (p. 190) PAPER #128
Predictors of Complications in Severe Open Fractures
Ida Leah Gitajn; *Sheila Sprague, PhD; Brad A. Petrisor, MD; Kyle J. Jeray, MD; Nathan O'Hara, MA; Jason Nascone, MD; Mohit Bhandari, MD; Gerard P. Slobogean, MD*

10:33 am Discussion

10:38 am Refreshment Break
Visit Scientific Posters & Technical Exhibits
(West Exhibit Hall B)

9:00 – 10:30 am **MINI SYMPOSIA** ***No Tickets Required***

Shoulder Girdle Injuries: Optimizing Decision Making and Surgical Management in 2017 *(West Meeting Room 109)*
Moderator: *Emil H. Schemitsch, MD*
Faculty: *Peter Cole, MD; Niloofar Dehghan, MD; Clifford B. Jones, MD; Frank Liporace, MD* and *Aaron Nauth, MD*

Fragility Fractures and Bone Health: Current State of the Art *(West Meeting Room 110)*
Moderator: *Michael J. Gardner, MD*
Faculty: *Kenneth A. Egol, MD; Kyle J. Jeray, MD; Clifford B. Jones, MD* and *Joseph Lane, MD*

Displaced Femoral Neck Fractures – What is the Evidence? *(West Meeting Room 111 & 112)*
Moderator: *John T. Gorczyca, MD*
Faculty: *Catherine Humphrey, MD; Robert Dunbar, MD; Kyle Judd, MD; Gillian Soles, MD* and *David Stephen, MD*

Anterior Approaches to the Acetabulum Can We All Just Get Along? *(West Meeting Room 114 & 115)*
Moderator: *Jason Nascone, MD*
Faculty: *Pierre Guy, MD; Keith Mayo, MD* and *Marcus F. Sciadini, MD*

See pages 401 - 442 for financial disclosure information.

10:38 am — Refreshment Break
Visit Scientific Posters & Technical Exhibits
(West Exhibit Hall B)

11:08 am - 12:40 pm **Concurrent Sessions**
(Mini Symposia and General Session run concurrently.)
Mini-Symposia (11:08 am - 12:38 pm)
Scientific Paper Session 7: General Interest (11:08 am - 12:40 pm)

11:08 am – 12:38 pm | **MINI SYMPOSIA** | *No Tickets Required*

Next Level: 8 Practices for Surgeon Wellness *(West Meeting Room 109)*
Moderator: *Jeffrey M. Smith, MD*
Faculty: *James Ficke, MD; Anna N. Miller, MD; Wade R. Smith, MD; Philip Stahel, MD* and *Todd Swenning, MD*

Limb Reconstruction and Amputation in Crisis and Conflict-Related Injuries *(West Meeting Room 110)*
Moderator: *Daniel Stinner, MD*
Faculty: *James Blair, MD; Jowan Penn–Barwell, MBBS; Joseph Hsu, MD* and *William Obremskey, MD*

The Treatment of Peri-Prosthetic Fracture in 2017: Can We Reach a Consensus *(West Meeting Room 111 & 112)*
Moderator: *Emil H. Schemitsch, MD*
Faculty: *George Haidukewych, MD; Michael D. McKee, MD; Aaron Nauth, MD; William M. Ricci, MD* and *Andrew Schmidt, MD*

Femoral Neck Fractures in the Young Adult: Are We Getting Better? *(West Meeting Room 114 & 115)*
Moderator: *Cory Collinge, MD*
Faculty: *Hassan Mir, MD; Christopher McAndrew, MD* and *John Scolaro, MD*

West Ballroom AB
11:08 am – 12:40 pm

SCIENTIFIC PAPER SESSION 7: GENERAL INTEREST

Moderators - Michael J. Gardner, MD & Stephen A. Kottmeier, MD

11:08 am
(p. 191)
PAPER #129

Wound Infections Following Implant Removal Below the Knee: The Effect of Antibiotic Prophylaxis: Results of the WIFI Trial, A Multicenter Randomized Controlled Trial
Siem A. Dingemans, MD*; Manouk Backes, MD; J. Carel Goslings, MD, PhD; Tim Schepers, MD, PhD*

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SATURDAY, OCTOBER 14, 2017

11:14 am (p. 192) PAPER #130
Screening for and Treating Intranasal Staphylococcus Carriage Correlates with Reduced Surgical Site Infections Complicating Operative Fracture Repair
***Abigail Cortez, BA**; James Burns, MS; Moses Lee, BA; Mariya Samoylova, BS; Eleni Berhaneselase, BA; Pouriya Ghayoumi, MD; Alexander A. Theologis, MD; Saam Morshed, MD, PhD*

11:20 am (p. 193) PAPER #131
Decreased Time to Antibiotic Prophylaxis for Open Fractures at a Level One Trauma Center
***Joseph Johnson, MD**; Avi Goodman, MD; Adam Haag, MD; Roman A. Hayda, MD*

11:26 am (p. 194) PAPER #132
Diagnostic Accuracy of Various Modalities Relative to Open Bone Biopsy for Detection of Long Bone Posttraumatic Osteomyelitis
Vivek Chadayammuri, BS; Herbert Benoit; Jiandong Hao; Juan Quispe; Ji-Wan Kim, MD; Heather Young; Mark Hake, MD;
Cyril Mauffrey, MD, FACS, FRCS

11:32 am Discussion

11:37 am (p. 195) PAPER #133
Significant Reduction of Intraoperative Material Costs Through Surgeon Intervention
***Laurence B. Kempton, MD**; Todd O. McKinley, MD; Greg E. Gaski, MD; Anthony T. Sorkin, MD; Walter W. Virkus, MD*

11:43 am (p. 196) PAPER #134
Operative Treatment of Tibial Plateau Fractures: Does a Submeniscal Arthrotomy Improve Long Term Patient Outcome? A Prospective Surgeon Randomized Clinical Trial
***Richard E. Buckley, MD, FRCPC**; Paul Duffy, MD; Robert Korley, MDCM; Emilia Rydberg Moller, MD; C. Ryan Martin, MD; Rafael Martinez Gallino, MD; Prism S. Schneider, MD, PhD*

11:49 am Discussion

11:54 am (p. 197) PAPER #135
Sleep Disturbance in Orthopaedic Trauma Patients
*Matthew Charles Swann, MD; **Miles Batty, BS**; Gene Hu, BS; Thomas Mitchell, BS; Hayden Box, MD; Adam J. Starr, MD*

12:00 pm (p. 198) PAPER #136
Inpatient Compliance with Venous Thromboembolism Prophylaxis in Orthopaedic Trauma: A Pragmatic Randomized Controlled Trial of Aspirin Versus Low Molecular Weight Heparin
***Bryce Haac, MD**; Richard Van Besien, BA; Nathan N. O'Hara; Gerard P. Slobogean, MD; Deborah Stein, MD, MPH; Robert V. O'Toole, MD; Theodore T. Manson, MD*

12:06 pm (p. 199) PAPER #137
Tranexamic Acid Use in High-Energy Pelvic, Acetabular, and Femoral Fractures
***Clay Spitler, MD**; Elliot Row; Warren E. Gardner; Michael Hankins; Rachel Swafford, MPH; Peter J. Nowotarski; Dirk William Kiner, MD*

12:12 pm Discussion

See pages 401 - 442 for financial disclosure information.

12:17 pm (p. 200) PAPER #138 — **How to Best Measure Changes in Clinical Status over Time: An Analysis of the Performance of Generic and Musculoskeletal Specific Functional Outcome Measures in Single Injury and Multiple Injury Patients**
Graham Sleat; *Kelly A. Lefaivre, MD; Pierre Guy, MD; Henry Broekhuyse, MD; Abdullah Mamun; Peter J. O'Brien, MD*

12:23 pm (p. 201) PAPER #139 — **Early Effects of the Trauma Collaborative Care Intervention: Results from a Prospective Multicenter Cluster Clinical Trial**
Stephen Wegener, PhD; *Kristin Archer, PhD; Michael Bosse, MD; Eben Carroll, MD; Joshua Gary, MD; Clifford Jones, MD; Anna Bradford Newcomb, PhD; Andrew N. Pollak, MD; Debra Sietsema, PhD; Heather A. Vallier, MD; Renan C. Castillo, PhD; Susan Collins, MSc; Katherine Frey, MPH; Yanjie Huang, MS; Daniel Scharfstein, PhD; Ellen MacKenzie, PhD; METRC Major Extremity Trauma Research Consortium*

12:29 pm (p. 202) PAPER #140 — **Predicting Completion of a Follow-up in Long Term Prospective Orthopedic Trauma Research**
Graham Sleat; *Kelly A. Lefaivre, MD; Pierre Guy, MD; Henry Broekhuyse, MD; Abdullah Mamun; Peter J. O'Brien, MD*

12:35 pm — Discussion

12:40 pm - 1:40 pm — Lunch and
Visit Scientific Posters & Technical Exhibits
Exhibit Hall closes at 1:45 pm
(West Exhibit Hall B)

12:55 – 1:40 pm — **LUNCHTIME GUIDED POSTER AND VIDEO TOURS** — ***Tickets Required***

(PT5) **Hip/Femur** *(West Exhibit Hall B)*
Guide: *Brett D. Crist, MD*

(PT6) **International** *(West Exhibit Hall B)*
Guide: *Peter V. Giannoudis, MD, FACS, FRCS*

(VT) **Video Tours** *(West Exhibit Hall B)*
Guide: *Kenneth Egol, MD*

1:40 pm - 3:59 pm — **Concurrent Sessions**
(Mini Symposia and General Session run concurrently.)
Mini-Symposia (1:40 pm - 3:10 pm)
Scientific Paper Session 8: Hip, Femur and Geriatrics (1:40 pm - 3:59 pm)

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1:40 pm – 3:10 pm | **MINI SYMPOSIA** | *No Tickets Required*

Complex Knee Dislocations *(West Meeting Room 109)*
Moderator: *William T. Obremskey, MD*
Faculty: *John Adams, MD; Frank Avilucea, MD* and *William Harvin, MD*

Controversies in Ankle Fractures *(West Meeting Room 111 & 112)*
Moderator: *John T. Gorczyca, MD*
Faculty: *John Ketz, MD; Raymond Wright, MD; Gillian Soles, MD* and *Kevin Pugh, MD*

The Joint Is a Mess, Now What? *(West Meeting Room 110)*
How to Restore Function when Intra-articular Fracture Surgery Fails
Moderator: *Emil H. Schemitsch, MD*
Faculty: *Michael D. McKee, MD; Chad Myeroff, MD; Aaron Nauth, MD* and *David W. Sanders, MD*

West Ballroom AB

1:40 pm – 3:59 pm

SCIENTIFIC PAPER SESSION 8: HIP, FEMUR and GERIATRIC

Moderators - Gilbert R. Ortega, MD & Gerard P. Slobogean, MD

1:40 pm
(p. 203)
PAPER #141
A Randomised Controlled Trial Comparing the Thompsons Versus the Exeter® Polished Taper Stem and Unitrax® Head in the Treatment of Displaced Intracapsular Fractures of the Hip: The WHiTE 3: HEMI Trial
Alex L. Sims; *Nick Parsons; Juul Achten; Xavier L. Griffin; Matthew L. Costa, PhD; Mike Reed*

1:46 pm
(p. 204)
PAPER #142
THR Versus Hemiarthroplasty for Displaced Intracapsular Fractures: Predicting Outcomes and Selecting Patients
Julie R. M. Craig, MB, BS; *Sinead McDonald; R. John Barr, MB, BS*

1:52 pm
(p. 205)
PAPER #143
Continuous Femoral Nerve Catheters Decrease Opioid-Related Side Effects and Increase Home Disposition Rates Among Geriatric Hip Fracture Patients
Diren Arsoy, MD; *Michael J. Gardner, MD; Stuart Barry Goodman, MD, PhD; William J. Maloney, MD; James I. Huddleston, MD; Derek F. Amanatullah, MD, PhD; Julius A. Bishop, MD*

1:58 pm
Discussion

2:03 pm
(p. 206)
PAPER #144
A Novel Tool to Predict Inpatient Triage and Hospital Quality Measures in the Geriatric Trauma Population at Time of Admission
Sanjit Reddy Konda; *Ariana Lott, BA; Hesham Saleh, MD; Thomas R. Lyon; Kenneth A. Egol, MD*

See pages 401 - 442 for financial disclosure information.

2:09 pm (p. 207) PAPER #145
Any Femoral Neck Shortening Post Fracture Fixation Negatively Impacts Functional Outcomes
Gerard P. Slobogean, MD; *Gregory J. Della Rocca, MD, PhD, FACS; Susan Liew; Robert Haverlag; Sheila Sprague, PhD; Nathan N. O'Hara; Marc F. Swiontkowski, MD; Mohit Bhandari, MD; FAITH Investigators*

2:15 pm (p. 208) PAPER #146
Gait Analysis Following Intertrochanteric Hip Fractures: Does Shortening Result in Gait Impairment?
Elizabeth Gausden, MD; *Ashley Levack, MD; Lauren Wessel, MD; Gele Moloney, MD; Danielle Sin, MS; Joseph M. Lane, MD; Dean G. Lorich, MD*

2:21 pm
Discussion

2:26 pm (p. 209) PAPER #147
Hip Fracture Patients on Non-Warfarin Anticoagulants: Is Surgical Delay Warranted?
Ariana Lott, BA; *Jack Haglin, BS; Rebekah Belayneh, BA; Sanjit Reddy Konda, MD; Philipp Leucht, MD; Kenneth A. Egol, MD*

2:32 pm (p. 210) PAPER #148
Δ Factors Associated with Revision Surgery Following Internal Fixation of Hip Fractures
Sheila Sprague, PhD; ***Emil H. Schemitsch, MD***; *Marc F. Swiontkowski, MD; Gregory J. Della Rocca, MD, PhD, FACS; Kyle J. Jeray; Susan Liew; Gerard P. Slobogean, MD; Diane Heels-Ansdell, BSc; Mohit Bhandari, MD; FAITH Investigators*

2:38 pm (p. 211) PAPER #149
Short Versus Long InterTAN Fixation for Geriatric Intertrochanteric Hip Fractures: A Prospective, Multicentre Head-to-Head Comparison
Michael Edward Sellan, MD; *Christina Tieszer, BSc; Diane Bryant; Steven Ray Papp, MD; Abdel-Rahman Lawendy; Timothy Carey, MD; J. Andrew Trenholm; Mark MacLeod; Darius G. Viskontas; Chad P. Coles; Wade T. Gofton; Trevor M. Stone; Allan S.L. Liew; Ross K. Leighton, MD; David W. Sanders, MD*

2:44 pm
Discussion

2:49 pm (p. 212) PAPER #150
Fixation Failure and Time to Reoperation After Internal Fixation of Young Femoral Neck Fractures: A Population-Based Study
David John Stockton, MD; *Lyndsay M. O'Hara, PhD; Nathan N. O'Hara; Kelly A. Lefaivre, MD; Peter J. O'Brien, MD; Gerard P. Slobogean, MD*

2:55 pm (p. 213) PAPER #151
Open Reduction is Associated with Greater Propensity-Stratified Hazard of Reoperation After Internal Fixation of Femoral Neck Fractures in Adults 18-65 Years of Age
Joseph Patterson, MD; *Keisuke Ishii, MD; Paul Tornetta III, MD; Darin Friess, MD; Clifford Jones, MD; Ross K. Leighton, MD; Ari Levine, MD; Brian H. Mullis, MD; William Obremskey, MD; Robert F. Ostrum, MD; Anas Saleh; Andrew H. Schmidt, MD; David C. Teague, MD; Antonios Tsismenakis, MD; J. Spence Reid, MD; Theodore Miclau III, MD; Saam Morshed, MD, PhD*

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.

SATURDAY, OCTOBER 14, 2017

3:01 pm (p. 214) PAPER #152	**Femoral Neck Stress Fractures: Clinical Course and MRI Risk Factors for Progression** ***Clarence Steele, MD***; *Grant Cochran, MD; Christopher Renninger, MD; Bradley Keith Deafenbaugh; Kevin M. Kuhn, MD*
3:07 pm	Discussion
3:12 pm (p. 215) PAPER #153	**Treatment of Femoral Neck Fractures in Patients 45 to 64 Years of Age** ***Joseph Johnson, MD***; *Justin Kleiner, BS; Avi Goodman, MD; Joseph A. Gil, MD; Alan H. Daniels; Roman A. Hayda, MD*
3:18 pm (p. 216) PAPER #154	**Is Distal Locking Necessary in Long Cephalomedullary Nailing of Intertrochanteric Fractures?** ***Hamid R. Mostafavi, MD***; *Arianna Caruso, BS; Margaret Cooke, MD; Andrew S. Lee, MD, MS; Nicholas A. Teri, BS; Paul Tornetta III, MD*
3:24 pm (p. 217) PAPER #155	**Early Comparative Outcomes of of Continuous Carbon Fiber-Reinforced Polymer Plate in Fixation of Distal Femur Fractures** *Adam K. Lee, MD; Phillip M. Mitchell, MD; Bruce H. Ziran, MD;* ***A. Alex Jahangir, MD***
3:30 pm	Discussion
3:36 pm (p. 218) PAPER #156	**New versus Old: A Prospective, Randomized Controlled Trial Comparing the 95° Angled Blade Plate with the Locking Condylar Plate for Distal Femur Fractures** ***Brendan M. Patterson, MD, MBA***; *Mary Alice Breslin, BA; Leanne Wadenpfuhl, BA; Heather A. Vallier, MD*
3:42 pm (p. 219) PAPER #157	**A Prospective Randomized Control Trial Comparing Immediate Weight Bearing Versus Touch-Down Weight Bearing in Extra-Articular Distal Femur Fractures** ***Daniel Allen Bravin, MD***; *David F. Hubbard, MD; Lindsey Bravin, MD; John C. France, MD; Michelle A. Bramer, MD*
3:48 pm (p. 220) PAPER #158	**Radiographic Healing of Far Cortical Locking Constructs in Distal Femur Fractures: A Comparative Study with Standard Locking Plates** ***Yanin Plumarom, MD***; *Michael Willey, MD; Yubo Gao, PhD; Brandon G. Wilkinson, MD; J. Lawrence Marsh, MD; Matthew D. Karam, MD*
3:54 pm	Discussion
4:00 pm	Closing Remarks and Adjourn
	See you next year in Orlando, Florida, October 17-20, 2018

See pages 401 - 442 for financial disclosure information.

Do Promising Biomechanical Research Studies Lead to Clinically Meaningful Results?

*Jason R. Kang, MD; **Grace Xiong**; Julius A. Bishop, MD*
Stanford Hospital & Clinics, Redwood City, California, USA

Purpose: Promising biomechanical effects in the laboratory setting often prompt questions about clinical relevance. The aim of this study is to (1) identify prospective randomized clinical trials (RCTs) comparing biomechanically distinct surgical interventions and (2) determine if promising biomechanical studies lead to clinically significant outcomes in orthopaedic surgery.

Methods: PubMed/SCOPUS databases were queried for the keywords: 'orthopedic or orthopaedic', and 'randomized controlled trial'. Inclusion criteria were: RCT, ≥2 treatment arms with biomechanically distinct surgical interventions, and existence of an analogous biomechanical study. Studies comparing operative versus nonoperative treatment, duplicate studies, and cadaveric studies were excluded. Statistical analysis utilized a contingency table and a mixed effects logistic regression model.

Results: Initial search returned 14,126 articles. Sports medicine (57%), trauma (22%), and spine (17%) composed the majority of RCTs comparing biomechanical interventions. 23 studies met inclusion criteria. In 17 (74%) of these studies, biomechanical research had identified one treatment that was superior to another. However, only 4 of 17 RCTs (24%) found that a biomechanically superior treatment led to an improved clinical outcome. The mixed effects logistic regression model demonstrated no concordance between the outcomes of biomechanical studies and RCTs.

		Clinically significant		
		Yes	No	Total
Biomechanically significant	Yes	4	14	18
	No	4	2	6
	Total	8	16	24

Conclusion: Orthopaedic implants and techniques with superior biomechanical properties are not associated with improved clinical outcomes when evaluated in RCTs. Surgeons should focus on variables other than biomechanical superiority in an effort to optimize surgical results.

Δ Validation of the Radiographic Union Score for Tibial Fractures (RUST) Using Medical Imaging and Biomechanical Testing in an In Vivo Rat Model

Sandra Fiset, MSc; Meghan C. Crookshank, MD; Charles Godbout, PhD; Radovan Zdero, PhD; Aaron Nauth, MD; ***Emil H. Schemitsch, MD***
St. Michael's Hospital, Toronto, Ontario, CANADA

Purpose: The Radiographic Union Score for Tibial Fractures (RUST) and its modified counterpart are gaining popularity as a standard for assessing fracture healing progress. RUST (score between 4-12) and modified RUST (score between 4-16) are based on callus formation and fracture line visibility at each of the 4 visible cortices in 2 radiographs. This study aims to validate the score's ability to accurately assess a bone's healing progression using imaging and biomechanical parameters.

Methods: A group of 30 male rats underwent a standardized osteotomy with noncritical gap stabilized with a PEEK (polyetheretherketone) bone plate. At their assigned end point ranging from 5-17 weeks, the healing femur was radiographed in the lateral and AP direction prior to being sacrificed and both femurs dissected. Two fellowship-trained orthopaedic surgeons independently assigned RUST and modified RUST scores to the healing femurs. Agreement among the 2 principal reviewers was calculated using intraclass correlation coefficients (ICCs). A microCT scan and torsional testing was performed on the fracture callus and contralateral femur. A Spearman's rank correlation coefficient was determined for the healing femur's scores and imaging and mechanical parameters.

Results: The ICC of the 2 reviewers was 0.89 (95% confidence interval [CI] 0.78-0.94) for RUST and 0.86 (95% CI 0.74-0.93) for modified RUST, which fall within the "almost perfect agreement" ICC category. The resulting RUST scores ranged from 6 to 12 and modified RUST scores ranged from 5 to 16. A moderate differential between the correlations of the 2 scoring systems with microCT parameters suggests that the modified score better characterizes the fracture callus in comparison to traditional RUST. Significant variability in mechanical properties was observed within individual RUST score groups, which may limit the score's ability to accurately predict the strength of an individual sample. However, it is noted that greater than 90% of contralateral load at failure is achieved by all samples at RUST ≥10 or modified RUST 15. This may provide a threshold above which a plated bone may be considered "healed".

Conclusion: RUST and modified RUST have strong relationships with imaging and biomechanical parameters providing evidence of the accuracy of the scores as assessment tools for fracture healing. Such a validated scoring system will provide researchers with a clinically relevant and widely comparable end point for studies pertaining to fracture healing.

Δ OTA Grant

See pages 401 - 442 for financial disclosure information.

Long Segment Blocking Screws (LSBS) Increase Stability of Retrograde Nail Fixation in Geriatric Supracondylar Femur Fractures: Eliminating the "Bell-Clapper Effect"

David Donohue; *Darryl A. Auston; Kyle Stoops; Miguel Diaz, MS*[1]; *Brandon Santoni, PhD*[1]; *Hassan R. Mir, MD*

[1]*Foundation for Orthopaedic Research and Education (FORE), Tampa, Florida, USA*

Purpose: This study was undertaken to determine the change in stiffness of a geriatric supracondylar femur fracture model with the addition of distal segment blocking screws versus proximal (long) segment blocking screws to the standard retrograde intramedullary nail construct.

Methods: Supracondylar femur fractures (AO/OTA 33-A3) were created in 12 osteoporotic, matched-pair, cadaveric femurs. These were instrumented with a retrograde intramedullary nail (R-IMN) and divided into 2 groups. Group 1 compared the standard construct (SC) to a construct augmented with blocking screws placed in the distal/short segment (SSBS). Group 2 compared the SSBS to a construct in which blocking screws were placed just proximal to the fracture in the long segment (LSBS). Specimens were then axially loaded and cycled to failure or runout. The main outcomes were (1) stiffness measured on a force/displacement graph during baseline assessment (axial load at 50 N) and cyclic loading for 10 K cycles at 3 Hz and (2) construct failure defined by actuator displacement of 15 mm above baseline.

Results: Group 1: There was no difference in stiffness at baseline ($P = 0.17$) or after 40 K cycles ($P = 0.34$) between the SC and SSBS. There was no difference in number of cycles to failure ($P = 0.330$). Group 2: LSBS specimens were significantly stiffer at baseline ($P = 0.023$) and after 40 K cycles ($P = 0.028$) compared to SSBS specimens. There was no difference in the number of cycles to failure ($P = 0.640$).

Conclusion: Blocking screw placement in the distal fracture segment provides no additional stability to the construct. Placement of LSBS significantly increases construct stiffness by eliminating the bell-clapper effect (Figure).

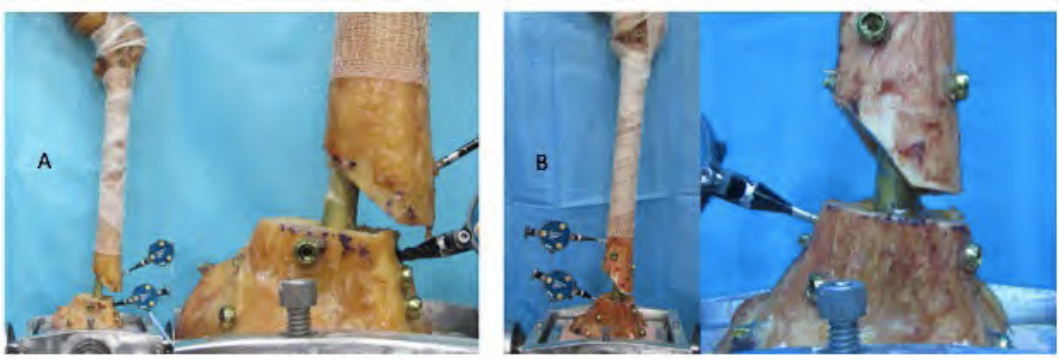


Figure 1. (A) Bell-clapper effect. Motion of the nail within the metadiaphysis/shaft with loading. (B) Addition of long segment blocking screws (LSBS) prevents bell-clapper effect.

Bridge Plating Ostosynthesis: Effect of Bridge Span on Interfragmentary Motion

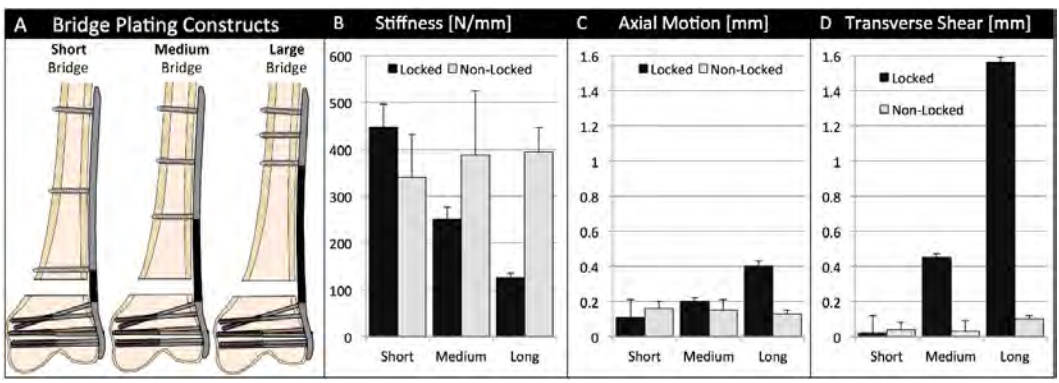
***Michael Bottlang**; Julia Henschel, MS; Stanley Tsai, MS; Daniel C. Fitzpatrick, MD; Steven M. Madey, MD*

Legacy Biomechanics Laboratory, Portland, Oregon, USA

Purpose: A long bridge span has been recommended to decrease the stiffness of locked plating constructs. This biomechanical study determined the effects of the bridge span on interfragmentary motion in locked and non-locked plating constructs.

Methods: Distal femur plates were applied to bridge a simulated AO type 33-A3 fracture. Plates were applied to yield a short, medium, or long bridging span (Fig. 1A). For locked constructs, diaphyseal locking screw configurations had a short (25 mm), medium (87 mm), or long (150 mm) bridge span (Fig. 1A). For non-locked constructs, non-locked screw configurations had a short (40 mm), medium (72 mm), or long (138 mm) bridge span. The effect of the bridge span on fracture stability was assessed by the axial construct stiffness, axial interfragmentary motion, and shear motion at the fracture site.

Results: For locked constructs, increasing the bridge span from 25 to 150 mm decreased stiffness by 72% ($P < 0.001$) and increased axial fracture motion from 0.1 mm to 0.4 mm ($P < 0.001$). It also increased shear motion to 1.56 mm ($P < 0.001$), leading to shear-dominant fracture motion (Fig. 1B-1D). For non-locked constructs, increasing the bridge span from 40 mm to 138 mm had no significant effect on stiffness, axial motion, or shear motion.



Conclusion: For locked constructs, long bridge spans induce shear-dominant motion, which can delay fracture healing. For non-locked constructs, longer bridge spans do not increase axial interfragmentary motion or shear motion. Therefore, a long bridge span may not be an effective strategy to promote natural fracture healing by interfragmentary motion, regardless if used with locked or non-locked screws.

See pages 401 - 442 for financial disclosure information.

Immune Dysregulation in a Rat Model of Infected Femoral Segmental Bone Defect

Hyunhee Ahn; ***Mara Schenker, MD****[1]; Rishin J. Kadakia; Pallab Pradhan; Laura D. Weinstock; Levi B. Wood; Krishnendu Roy; Robert E. Guldberg; Nick J. Willett*
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Purpose: Open contaminated fractures are a clinical challenge. Morbidity includes impaired bone healing, infected nonunion, osteomyelitis, and associated hardware failure. In the setting of trauma and infection, it has been proposed that immune dysregulation can further impair healing. The purpose of this study was twofold: to establish a clinically relevant model of infected segmental bone loss, and to investigate the effects on immune response.

Methods: 13-week-old rats underwent unilateral noncritical femur bone defects surgery with plate stabilization. Animals were placed in 1 of 3 groups: naïve (no surgery, n = 2), control (segmental defect only, n = 2), and infection (segmental defect + infection, n = 4). The infection group received a gelatin sponge soaked with luciferase expressing *Staphylococcus aureus* (Xen 29; 10^4 CFU). Bacterial growth was monitored by bioluminescence. Radiographic imaging was performed every 2 weeks. The end point was at 12 weeks, but animals were euthanized if hardware failure was observed. Bacterial contamination confirmed by wound culture and systemic immune response was measured by serum ELISA (enzyme-linked immunosorbent assay), collected upon euthanasia. Luminex data were analyzed by D-PLSR modeling in MATLAB with the partial least squares algorithm by Cleiton Nunes. MicroCT scans were performed to quantify bone bridging and periosteal growth.

Results: Bioluminescent signal appeared in infection animals at day 3 post-surgery and was present up to day 7. In the infection group, serial radiographs showed no bridging at any time point, with 3 of 4 with hardware failure. Inspection of the thighs of euthanized infected animals demonstrated deep purulence. Bacterial cultures were positive for the infection group and negative for the controls. Infected rats had increased expression of immune suppressive cytokines (interleukin [IL]-10) and reduced concentration of inflammatory cytokines (tumor necrosis factor [TNF]-α, IL-1). Flow cytometry showed increased myeloid-derived suppressor cells (MDSCs) and Tregs population in spleens from infected animals.

Conclusion: We present a novel clinically relevant infected rat segmental bone defect model with associated hardware failure. Serum samples from infected animals possessed lower concentrations of key proinflammatory cytokines and an increase in immunosuppressive cell populations (eg, MDSCs) in the spleen, suggesting chronic systemic immune dysregulation due to the infection. While these preliminary results are promising, further work is ongoing to perform histology, increase sample sizes, and optimize control groups.

Intrawound Vancomycin Powder Reduces *Staphylococcus aureus* Surgical Site Infections in a Rabbit Model

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Purpose: A technique that is gaining popularity to reduce the risk of surgical site infection and hardware colonization after fracture fixation surgery is the application of local vancomycin powder intraoperatively. However, there has been little basic science evidence to validate its efficacy in orthopaedic trauma patients. We hypothesize that application of vancomycin powder to the surgical sites in a rabbit model of plate fixation contaminated with methicillin-resistant *Staphylococcus aureus* (MRSA) will demonstrate a decrease in the risk of surgical site infection.

Methods: All of the surgical sites were then seeded with 1 x 10^8 CFU of MRSA. 125 mg (estimated to be equivalent to a 1000-mg dose for a human) of vancomycin powder was applied to 9 of the rabbits (treatment group) and the other 9 did not have vancomycin powder (control group). Serum vancomycin levels were measured at scheduled time points over 24 hours. Tibias and implants were harvested at 2 weeks from implantation to determine bone infection and implant biofilm formation based on the number of bacterial colony-forming units. Radiography, histology, and electron microscopy aided in evaluation. Outcomes were compared using a Fisher exact test with $P < 0.05$ set as significant.

Results: No bone infection or implant colonization occurred in the vancomycin powder group. Six bone infections and 6 implant biofilm formations (67%; 95% confidence interval, 45%-88%) occurred in the group that did not receive vancomycin powder ($P = 0.009$). Serum vancomycin levels were detectable at minimal levels at 1 and 6 hours only. Pathological changes occurred in the specimens that were positive for infection.

Conclusion: This study demonstrates that the application of vancomycin powder at the time of hardware implantation to a surgical site seeded with MRSA decreases risk for infection of the bone and colonization of implants in a rabbit model, with minimal increase in serum vancomycin levels. The results are encouraging and support the rationale for a clinical trial investigating the use of local intraoperative vancomycin powder to reduce the rate of surgical site infections.

See pages 401 - 442 for financial disclosure information.

Intrawound Vancomycin Powder Reduces Bacterial Load in Contaminated Open Fracture Model

Cyrus Theodore Caroom, MD[1]*; Dustin Moore, MD*[1]*; Nithya Mudaliar, MS*[1]*; Craig Winkler, MD*[1]*; Jefferson Jacob Murphree, MD*[1]*; Ian Ratheal, MD*[1]*; Michael Fry, BS*[1]*; Jessica Tullar, PhD, MPH*[2]*; Abdul Hamood, PhD*[1]

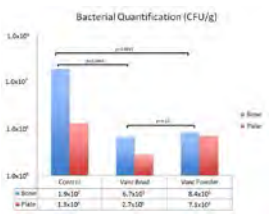
[1]*Texas Tech University Health Sciences Center, Lubbock, Texas, USA*

[2]*University of Texas Health Science Center School of Public Health, Texas, USA*

Purpose: Intrawound application of vancomycin powder has shown to decrease surgical site infection rates in both cardiac and spine surgery in retrospective studies. Polymethylmethacrylate (PMMA) beads infused with antibiotic powder have been used in the treatment of open fractures to decrease rates of infection, but require removal at a later time. The purpose of this study was to compare the effectiveness of both vancomycin powder and antibiotic bead placement to irrigation and debridement alone in prevention of infection in a contaminated open fracture model in rats.

Methods: In a previously described model of contaminated open fractures, 45 400-g Sprague-Dawley rats had simulated open fractures created, stabilized, and contaminated with 10^5 CFU of *Staphylococcus aureus*. They were then treated 6 hours later with 3 interventions: irrigation and debridement alone (control group), irrigation and debridement with placement of PMMA beads containing vancomycin and tobramycin powders (antibiotic bead group), and irrigation and debridement with placement of 10-mg intrawound vancomycin powder (powder group). Rats were allowed to recover and then 14 days later sacrificed for harvest of femurs and plates. Femurs and plates were both incubated overnight and bacterial colonies were counted in each group for comparison.

Results: Specimens taken from control and powder groups showed bacterial growth in 30 of 30 samples. Specimens from the bead group showed growth in 26 of 30 samples ($P = 0.48$). Quantitative counts of bacteria in bone showed significantly reduced growth in both bead (6.7×10^5) and powder (8.4×10^5) groups when compared to controls (1.9×10^7); $P < 0.0001$. Quantitative counts of bacteria in plates showed significantly reduced growth in both bead (2.7×10^5) and powder (7.1×10^5) groups when compared to controls (1.3×10^6) ($P < 0.0003$; 0.029). No significant differences were seen in bacterial growth between bead and powder groups for either bones ($P = 0.13$) or plates ($P = 0.065$).



Comparison of Groups by Quantitative Cultures of Recovered Bacteria from Bone and Implant Samples (Mann-Whitney Test) and Presence or Absence of Bacteria in Samples (Fisher's Exact Test)

Comparison		Mann-Whitney Test		
Group 1	Group 2	Bone	Plate	Fisher's exact test
Control	Bead	<0.0001	0.0003	0.483
Control	Powder	<0.0001	0.0294	NA
Bead	Powder	0.13	0.0649	0.483

Conclusion: When compared to irrigation and debridement alone, placement of intrawound vancomycin powder significantly decreased bacterial load in a contaminated open fracture model in rats similar to placing antibiotic beads. This may provide an additional adjuvant treatment that does not require a secondary surgery for bead removal.

Release of Vancomycin and Tobramycin from PMMA Cements Impregnated with Calcium Polyphosphate Hydrogel

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[2]*Wayne State University, Detroit, Michigan, USA*

Purpose: The goals of this study were to determine the release of vancomycin (Vanco) and tobramycin (Tob) from calcium polyphosphate (CPP) gel-doped PMMA (Simplex P, SP), and investigate the influence of the impregnation of CPP gel on the mechanical strength, handling and cellular growth of SP cement.

Methods: The SP powder was mixed with liquid, followed by the addition of 10% CPP gel (w/w) to form SP/CPP composite (SPC). A combination of 0.225 g of Vanco and 0.27 g of Tob per 3.0 g of SP were mixed with the SP powder prior to adding the liquid (SP + VT). For SPC, the same amounts of antibiotics were mixed with CPP gel prior to mixing with the SP powder for setting (SPC + VT). The antibacterial activity of eluted antibioticsA was measured. The interaction of antibiotics with CPP was investigated using Raman. The surface roughness and pore sizes were analyzed by microCT, AFM and SEM. The handling and compressive strength were tested. MC3T3 cells were used to evaluate in vitro biocompatibility.

Results: Adding 10% CPP gel to SP led to a much lower burst release of Vanco and considerably extended release of both Vanco and Tob up to 24 weeks. At the end of 24 weeks, the release of Tob (68.8 ± 12%) and Vanco (92.7 ± 5.5%) from SPC is higher than that of SP (52.5 ± 3.3% and 85.6 ± 13%, respectively). Antibiotics released from SPC retain their bactericidal activity. The improvement in the antibiotic release kinetics is mainly due to the molecular interactions of antibiotics with embedded CPP polyphosphate chains as confirmed by Raman analysis. The inclusion of CPP hydrogel also increased the SP surface roughness, hydrophilicity, and pore sizes, leading to a higher release rate of antibiotics. The SPC cement is biocompatible and has similar handling properties and mechanical strength as compared to SP cements.

Conclusion: In this work, we found that the SPC significantly reduced the burst release of Vanco/Tob, and sustained the antibiotic release for up to 24 weeks. Our data suggest that the improvement in antibiotic release of SPC is mainly due to the intermolecular interaction of antibiotics with embedded CPP polyphosphate chains (reduction of burst release and sustained release coupled with slow degradation of CPP). In addition, the higher release rate of antibiotics from SPC may be due to the increase of surface roughness, hydrophilicity, and pore sizes in the presence of CPP. Furthermore, SPC is biocompatible and the handling properties and mechanical strength of SP are not sacrificed. We believe that SPC represents a better drug carrier of PMMA cement. Its long-term mechanical performance warrants further investigation in vivo.

See pages 401 - 442 for financial disclosure information.

Synovial Fluid Analysis Reveals a Novel Panel of Biomarkers Altered Following Articular Fracture

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[1]*Duke University, Durham, North Carolina, USA*
[2]*Washinton University, St. Louis, Missouri, USA*

Purpose: There are currently no effective screening methods to determine who is at risk for developing posttraumatic arthritis (PTA). This is a prospective observational cohort study with an overall objective to identify changes in synovial biomarkers following articular fracture that are associated with joint injury that may be predictive of the development of PTA.

Methods: Patients with unilateral articular fracture of the knee were enrolled in an IRB- and USAMRMC HRPO-approved study. 8 patients (50% female; 25-83 years of age; average body mass index 32.4 kg/m^2) had synovial fluid (SF) collected by direct aspiration from both the fractured (Fx) and contralateral non-fractured (Non-Fx) knee. SF was stored at -80° until analyses. Enzyme-linked immunosorbent assays were used to quantify SF levels of 40 acute markers of joint metabolism (8 analytes). Joint biomarkers included matrix metalloproteinase (MMP)-1, -2, -3, -9, and -10, COMP (cartilage oligomeric matrix protein), sulfated glycosaminoglycans (sGAG), and C-telopeptide of type II collagen (CTXII). Paired t tests were used to test the differences of biomarkers in SF between the injured limb (Fx) and the contralateral control limb (Non-Fx). The Benjamini-Hochberg (BH) method was used to control for false discovery rate (FDR) due to multiple testing. Biomarkers meeting BH-adjusted $P < 0.05$ were identified. Ingenuity Pathway Analysis (IPA) was used to identify pathways of relevance.

Results: Comparisons of biomarker concentrations in SF from Fx and Non-Fx knees identified 16 analytes of the 48 measured having significantly higher concentrations in SF from the fractured knee. These biomarkers were associated with inflammatory response (14 of 16) and injury (15 of 16) and are illustrated as they are associated with molecular events following fracture. Upon injury, vascular disruption occurs resulting in the release of biomarkers of angiogenesis (vascular endothelial growth factor [VEGF], VEGF-C, VEGF-D, PIGF), which upregulate the expression of MMPs. This is followed by an inflammatory stage in which macrophages and other immune cells are recruited to the fracture sites and secrete proinflammatory cytokines (interleukin [IL]-4, IL-8, IL17a, tumor necrosis factor [TNF]-α), resulting in synovitis and eventual cartilage degradation.

Conclusion: Identification of the inflammatory mediators involved in acute injury may provide key insights into potential adjunctive therapies that could improve outcomes following surgery. In addition, the patterns of biomarkers following acute injury may aid in risk stratification and identification of those at highest risk for developing PTA.

Hemorrhagic Shock and Surgical Strategy (Nailing versus External Fixation) Affect the Microcirculation in Soft Tissues

Roman Pfeifer, MD[1]*; Klemens Horst, MD*[2]*; Zhi Qiao; Michel Teuben; Frank Hildebrand, MD*[2]*; Hans-Christoph Pape, MD*[3]

[1]*Department of Trauma Surgery, Zürich, SWITZERLAND*

[2]*RWTH Aachen University Clinic, Aachen, GERMANY*

[3]*University Hospital Zürich, Division of Trauma Surgery, Department of Surgery, Zürich, SWITZERLAND*

Purpose: Soft tissues are of immense importance for bone healing and local and systemic inflammatory response. The effects of bleeding and surgical intervention on soft-tissue microcirculation are not fully understood. In this analysis we have measured alterations of microcirculation in soft tissues associated with hemorrhagic shock and surgical strategy after femoral fracture.

Methods: Male pigs (German Landrace, weight 30 ± 3 kg) were subjected to standardized lung contusion (bolt shot, 9 × 17 Dynamit Nobel), femoral fracture, liver laceration, and controlled hemorrhage (HS) (mean arterial pressure [MAP] 40 ± 5mm Hg) for 90 minutes. Local microcirculation was measured using O²C (oxygen to see) device. The following parameters were obtained: blood flow (Flow), the oxygen saturation (SO^2), and relative hemoglobin amount (rHb). During HS, microcirculation was measured on healthy muscle (M. vastus lateralis). Femoral fracture was stabilized either with intramedullary nailing or with external fixation. Microcirculation was measured daily on the fracture site of these animals. The observation period of this study was 3 days.

Results: Over the observation period, after HS we have measured a significant increase of Flow and elevated local SO^2 and rHb. All these parameters indicate a presence of hyperemia in soft tissues after hemorrhage and resuscitation. In addition, reduced microcirculation in musculature was observed after fracture treatment with external fixation on day 2 and 3. Intramedullary nailing was associated with no differences of Flow, SO^2, and rHb in comparison to the noninjured site.

Conclusion: In this study, we observed changes in microcirculation during the trauma and shock phases. Furthermore, we also measured persistent dysfunction of the microcirculation over the observation period of 3 days after resuscitation and HS. This might be of importance in development of local and systemic inflammation. Moreover, external fixation led to reduced microcirculation in musculature. This fact might also affect the rates of infection and bone healing.

See pages 401 - 442 for financial disclosure information.

The Gut Microbiome: What Effect Does Our Diet Play in Fracture Healing?

Ashlee MacDonald, MD; *Christopher Farnsworth, PhD Student; Eric Schott, PhD Student; Alex Grier; Steven Gill, PhD; Hani Awad, PhD; Michael Zuscik, PhD; Robert Mooney, PhD; John P. Ketz, MD*
University of Rochester, Rochester, New York, USA

Purpose: Obesity is a risk factor for delayed fracture healing and nonunion. Associated with this is a recognition of the influence the gut microbiome has on systemic inflammation, which can be altered with prebiotics. Our prior study showed delayed fracture healing with increased adipocytes and decreased biomechanical strength in obese mice compared to lean mice in a tibial shaft fracture model. The purpose of our study was to evaluate the effect of the prebiotic oligofructose on fracture repair and callus morphology in mice fed lean and high-fat diets (HFDs).

Method: 20 male mice were fed a lean or high-fat diet for 12 weeks. They were divided into 2 secondary groups supplemented with oligofructose or a control nondigestible fiber for 2 additional weeks. A reproducible tibia fracture was surgically administered and stabilized with an intramedullary needle. At the time of sacrifice (21 days post-fracture), fecal samples were collected and analyzed to determine the bacterial load present using 16S rDNA sequencing. Microcomputed tomography images were obtained to evaluate the volume of mineralized callus. Tibiae were prepared for histological analysis. Histomorphometric analysis of the fracture callus was performed by a blinded observer.

Results: In the absence of oligofructose, HFD was associated with a significant increase in % adipocyte area in the callus compared to lean-fed mice. With oligofructose, % adiposity normalized to the phenotype of the lean-fed mice. Histological analysis showed an increased amount of mature, remodeled callus in the lean mice versus the HFD group. Callus size was significantly larger in the mice fed HFDs with cellulose compared to lean fed mice, suggesting delayed callus remodeling. With oligofructose, this normalized to that of the lean mice. The rescue of the phenotype corresponded with a shift in the gut microbiome. Bifidobacterium pseudolongum, a known beneficial microbe, was more abundant in mice fed oligofructose. Several detrimental inflammatory species that were increased in obese mice were suppressed with oligofructose.

Conclusion: Oligofructose decreases adiposity and reverses the callus phenotype in obese mice to that of lean mice. Oligofructose resulted in alterations in the gut microbiome favoring a healthy inflammatory environment. Our data suggest that impaired fracture repair in obesity is linked to an inflammatory process driven by an altered gut microbiome, and prebiotic strategies can restore a healthy microbial profile.

Can Intramuscular pH Levels Diagnose Acute Compartment Syndrome?

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Purpose: Acute compartment syndrome (ACS) impacts many trauma patients. Intracompartmental pressure measurements are the current standard of care but have been shown to have important limitations. We hypothesized that pH would be sensitive and specific for determining muscle hypoxia and therefore for diagnosing ACS.

Methods: Compartment syndrome was created in 11 anesthetized adult mixed-sex beagles. ACS was created in the craniolateral compartment of a lower leg by infusion of lactated Ringer's solution. Compartment pressure and pH were recorded with commercially available probes. Our primary outcome measures were intramuscular pH.

Results: Mean arterial pressure averaged 67 mm Hg during the experiment. The compartment pressures were maintained at an average of 86 mm Hg in the experimental limb and an average of 15 mm Hg in the control limb. The initial intramuscular pH concentrations were similar in the experimental and control limbs (6.85 vs 6.85, P = 0.94). The final pH in the experimental limb was 6.28 versus 6.79 in the control limb (P <0.001). The control and experimental groups were significantly different 45 minutes after ACS creation (6.68 control vs 6.45 experimental, P = 0.001). Using a pH threshold of 6.3 or less, our data were 72.7% (39.3%-92.7%; 95% confidence interval [CI]) sensitive and 100% (57.1%-99.5%; 95% CI) specific for compartment syndrome. Receiver operating characteristic curve analysis for pH demonstrated 0.875 area under the curve.

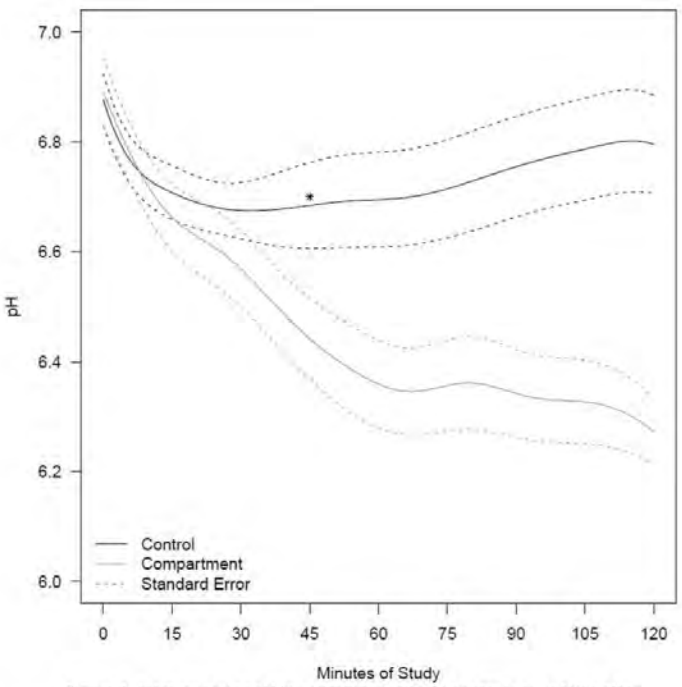

Figure 1. Intramuscular pH in control and experimental legs vs time after ACS creation.

* denotes statistical significance (p < 0.001)

Conclusion: This study describes a novel technique for diagnosing ACS in a canine model. Our results are promising and show that intramuscular pH identifies muscle ischemia within 45 minutes of ACS creation with decent sensitivity and high specificity in this animal model and further work should be aimed at refining this technology.

See pages 401 - 442 for financial disclosure information.

Designer Chimeric Protein BV-265 Composite Matrix Demonstrates Efficacy in Nonhuman Primate Bone Repair Models at Substantially Lower Concentrations than BMP-2/Absorbable Collagen Sponge

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Purpose: This study demonstrates a chimeric protein/composite matrix (BV-265/CM) is efficacious at substantially lower concentrations in nonhuman primate bone repair models than bone morphogenetic protein (BMP)-2/absorbable collagen sponge (ACS). BV-265 optimizes BMP receptor binding by combining amino acid sequences from BMP-2, BMP-6, and Activin A. The CM, containing calcium-deficient hydroxyapatite granules embedded in a fenestrated, polymer mesh reinforced, macroporous recombinant human type I collagen matrix was engineered for optimal BV-265 retention.

Methods: 2-cm pin-stabilized fibula defects created in adult macaques were untreated (n = 3), treated with CM (n = 3), or treated with 0.05 or 0.15 mg/cc BV-265/CM (n = 6 each). Bilateral pin-stabilized fibula wedge osteotomies created in 3 adult baboons were treated with 0.15 mg/cc BV-265/CM. Radiographs were obtained at 2-week intervals for 12 weeks. Explanted fibulae were evaluated with μCT, torsional biomechanics, and histology.

Results: Untreated and CM-treated defects were not bridged at 12 weeks. Defects treated with 0.05 and 0.15 mg/cc BV-265/CM were bridging at 12 weeks. Defects treated with 0.05 mg/cc BV-265/CM demonstrated more uniform bone formation compared to the rapidly formed neocortex observed bridging the 0.15 mg/cc BV-265/CM-treated defects. Callus volume was 423 ± 197 mm^3 and 574 ± 42 mm^3, respectively, in the 0.05 and 0.15 mg/cc BV-265/CM-treated defects ($P < 0.05$). Maximum torque was 0.70 ± 0.06 Nm (52% of intact fibulae) and 1.04 ± 0.1 Nm (78% of intact fibulae), respectively, for the 0.05 and 0.15 mg/cc BV-265/CM-treated defects. Torsional stiffness was 0.033 ± 0.01 Nm/deg (34% of intact fibulae) and 0.063 ± 0.01 Nm/deg (66% of intact fibulae), respectively, for the 0.05 and 0.15 mg/cc BV-265/CM-treated defects. CM-treated defects failed mechanical testing. Wedge osteotomies treated with 0.15 mg/cc BV-265/CM united by 8 weeks and continued to remodel through 12 weeks. Maximum torque was 200% greater (5.6 ± 1.3 Nm vs 2.7 ± 0.5 Nm, respectively, $P < 0.001$) and torsional stiffness was 150% greater (0.3 ± 0.01 Nm/deg vs 0.2 ± 0.1 Nm/deg, respectively, $P < 0.001$) than the values for intact fibulae.

Conclusion: This study demonstrates BV-265/CM can bridge macaque fibula defects and baboon fibula wedge osteotomies at 1/10 to 1/30 the BMP-2/ACS concentration reported to unite nonhuman primate fibula osteotomies.

Adjunctive Immunomodulation Improves Efficacy of Autologous Minced Muscle Graft in a Porcine Model of Volumetric Muscle Loss

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Purpose: Volumetric muscle loss (VML) resulting from extremity trauma presents chronic and persistent functional deficits, restricted joint range of motion, and fibrosis, which cause disability. Current translational efforts attempt to promote regeneration of the muscle ablated by the original trauma, with 2 potential therapies currently feasible for human application, acellular biological scaffolds and autologous minced muscle grafts (~1 mm^3 pieces of muscle tissue). We investigated the use of autologous minced muscle grafts, which is currently limited by the burden of autologous muscle tissue from a donor site. Our objective was to explore adjunct pharmacological immunomodulation to enhance graft performance and thereby reduce the donor tissue required. We hypothesized that repair of VML injuries by replacing ~50% of the defect mass with autologous minced muscle graft would improve neuromuscular function and that systemic immunomodulation using tacrolimus, a US Food and Drug Administration (FDA)-approved immunosuppressant, would enhance recovery of muscle strength.

Methods: Female Yorkshire Cross pigs (n = 7) were randomized to sham or a ~20% VML injury to the peroneous tertius muscle, and injuries were left nonrepaired, or surgically repaired with an autologous minced muscle graft derived from the adjacent injury; immediately following surgery animals were randomized to 1 month of immunomodulation using tacrolimus (Prograft, Astellas Pharam Inc; 0.075 mg/kg daily). Analysis of muscle function via peroneal nerve stimulation was conducted biweekly over 12 weeks.

Results: In vivo isometric torque was not different before surgery among surgical groups and the sham strength response through 12 weeks was stable (P = 0.121). From 2 to 12 weeks postinjury the nonrepaired VML group presented a ~28% strength deficit and delivery of tacrolimus in the nonrepaired did not ameliorate the strength deficit (~24%). However, graft repair with systemic tacrolimus tended to reduce the functional deficit approximately one-third to ~19% (P = 0.056).

Conclusion: Delivery of adjunctive tacrolimus with an autologous minced grafts at a ~50% replacement by mass of the original volumetric defect can promote modest recovery of isometric strength. Notably, delivery of ~50% minced grafts to the VML defect without adjunctive immunomodulation did not promote recovery of strength, which is contrary to prior reports in which a ~100% replacement promoted functional recovery. Further basic exploration of the interaction of immunomodulation and myogenesis is needed.

See pages 401 - 442 for financial disclosure information.

Δ Effect of Cold Therapy on Bone Healing

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Purpose: The purpose of this study is to investigate the effect of local cold therapy on bone healing. The hypothesis is that the group exposed to cold therapy will show more signs of healing in both microCT and histologic analysis when compared to the control group.

Methods: Twelve C3H wild-type mice aged 2-3 months were used in the study. A 1-mm burr was used to create a 1 × 3 mm unicortical rectangular bone window in the lateral aspect of the femoral diaphysis. The right side was designated as the experimental side in all mice. A temperature sensor implanted on the quadriceps of the index mouse was able to confirm that using a 6°C cold bath, the legs were cooled down to 19°C within 3 minutes. The experimental side was immersed daily in a 6°C cold bath for a total of 15 minutes. A total of 12 mice underwent the abovementioned protocol without complications. MicroCT analysis was performed using a Skyscan 1172 microCT (Bruker Corp). A region of interest (ROI) was defined using a 1-mm fixed diameter circle centered on the medullary canal. A constant total volume (TV) was created by extrapolating the ROI over a distance of 2.3 mm, centered at the middle of the cortical defect. Using a threshold of 55 Hounsfield units, the total bone volume (BV) was extrapolated from the ROI. For histologic analysis, the femora were fixed and cut in 5-μm sections. Staining for alkaline phosphatase (ALP), CD34, and tartrate-resistant acid phosphatase (TRAP) was then performed.

Results: The average bone window length was 2.68 ± 0.16 mm. The percent bone volume (BV/TV) in the experimental group was 34.1 ± 5.0, which was significantly higher than that of the control group 26.9 ± 7.1 ($P < 0.001$). Histological analysis revealed a significant decrease ($P < 0.001$) in the percentage of ALP stained cells in the experimental group (0.44 ± 0.2) when compared to the control group (1.2 ± 0.4). There was also a significant decrease ($P = 0.03$) in the percentage of CD34 stained cells in the experimental group (0.22 ± 0.08) when compared to the control group (1.58 ± 0.6). Finally, there was no significant difference ($P = 0.4$) in the percentage of TRAP stained cells between both groups ($P = 0.4$).

Conclusion: The results of our experiments show that daily treatments with cold therapy stimulate the bone growth/healing process in our murine model. Furthermore, the histological analysis reveals that the mechanism by which cold therapy stimulates growth is not necessarily linked to osteoblast activity since osteoblast activity was not increased in the experimental group despite increased bone formation. Further studies aimed to characterize the mechanism of action of cold therapy on bone healing are warranted based on the results of this pilot study.

Δ OTA Grant

Hypoxic Preconditioning of Mesenchymal Stem Cell Spheroids Stimulates Segmental Bone Defect Repair

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Purpose: The transplantation of mesenchymal stem cells (MSCs) holds great potential for use in musculoskeletal repair and addressing many shortcomings of existing therapeutic approaches. However, this approach is limited clinically due to poor cell survival and engraftment in vivo. Short-term preconditioning of MSCs under hypoxic conditions can promote cell viability and sustain persistence in vivo, and we demonstrated that MSCs formed into spheroids can be effectively deployed within a clinically relevant hydrogel to enhance their therapeutic potential for bone tissue engineering applications.

Method: Human MSCs were preconditioned in 1% O2 in monolayer culture for 3 days (PC3) or kept in ambient air (PC0), formed into spheroids of 3 different sizes (3,000, 10,000, or 15,000 cells/spheroid), and then entrapped at equal cell densities in alginate modified with the adhesive peptide RGD. We measured MSC viability and secretion of vascular endothelial growth factor (VEGF) over 4 days in serum-deprived/hypoxic conditions. Osteogenic potential of spheroids in alginate gels was determined by measuring alkaline phosphatase (ALP) activity and calcium deposition over 14 days in osteoinductive conditions. Alginate gels containing PC3 spheroids suspended at 30 million cells/mL were then implanted into a 6-mm critical-sized segmental defect in the right femora of athymic rats. Bone healing was evaluated over 12 weeks.

Results: The preconditioning of MSCs prior to spheroid formation exhibited beneficial effects on MSC survival and trophic factor secretion in vitro. Caspase 3/7 activity, an indicator of apoptosis, significantly decreased in PC3 groups compared to unconditioned controls. VEGF secretion, a key hallmark of proangiogenic potential, was greatest in PC3 spheroids. Secreted VEGF levels remained constant over 4 days for each spheroid size. MSCs formed into spheroids possessed robust osteogenic potential, with the largest spheroids (15,000 cells/spheroid) exhibiting increased ALP activity and calcium deposition over 14 days compared to other groups.

Conclusion: These data demonstrate that preconditioning of MSCs prior to spheroid formation and entrapment in RGD-modified alginate hydrogels promotes cell viability, proangiogenic potential, and bone healing. Our study is the first to demonstrate significant spheroid-mediated bone healing of a critical-sized segmental defect without the use of BMP-2.

See pages 401 - 442 for financial disclosure information.

Δ Platelet-Rich Plasma as a Vehicle for Endothelial Progenitor Cell Delivery in Critical-Sized Bone Defects

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Purpose: Endothelial progenitor cells (EPCs) have successfully been used to promote bone repair in many different preclinical fracture models. However, to date, investigation in this area has relied on the use of cell culture media or saline for the therapeutic delivery of these cells. Recently, platelet-rich plasma (PRP) has been found to stimulate profound recruitment, proliferation, and differentiation of various stem and progenitor cells. Therefore the purpose of this study was to investigate the use of PRP and its effect on the ability and efficacy of EPCs to regenerate bone in a rodent critical-size defect model. We hypothesized that the use of PRP as a carrier for EPCs would improve bone healing when compared to the conventional EPC carriers including culture media, saline, or platelet-poor plasma (PPP).

Methods: A collagen scaffold seeded with ex vivo expanded EPCs (suspended in saline, PPP, PRP, or cell culture media) was placed in a surgically created 5-mm bone defect in the right femur of male rats. Controls of PPP and PRP with no cells were also used. The cells used for implantation were isolated from a sacrificed rat whose bone marrow was cultured for 7 days, while the PRP and PPP was isolated from rat peripheral blood via a 2-stage centrifugation process. Bone healing was assessed with biweekly radiographs, microCT analysis, and biomechanical testing. All animal protocols were approved by the Hospital Animal Care Committee.

Results: Radiographs demonstrated that bony union was achieved (irrespective of the carrier) in all but one of the EPC-treated animals. Notably, animals receiving PPP or PRP alone did not demonstrate any osseous bridging of their defects. MicroCT analysis further revealed a significant increase in the volume of bone regenerated among EPC-treated animals when compared to non-EPC-treated. Biomechanical testing confirmed unstable nonunion in both the PRP and PPP control groups, and crucially showed no significant differences in strength among any treatment groups receiving EPCs.

Conclusion: The use of PRP for regenerative applications in orthopaedics is appealing due to its ease of isolation and its biocompatibility. However, this study showed no significant benefit of PRP over conventional carriers for EPC therapy. Taken altogether, the results of this investigation identify saline as an appropriate and clinically relevant carrier for EPC therapy due to its efficacy, low cost, and noninvasiveness.

Δ OTA Grant

Δ Aminocaproic Acid Inhibits Periosteal Chondrogenesis and Promotes Periosteal Osteogenesis During Fracture Healing

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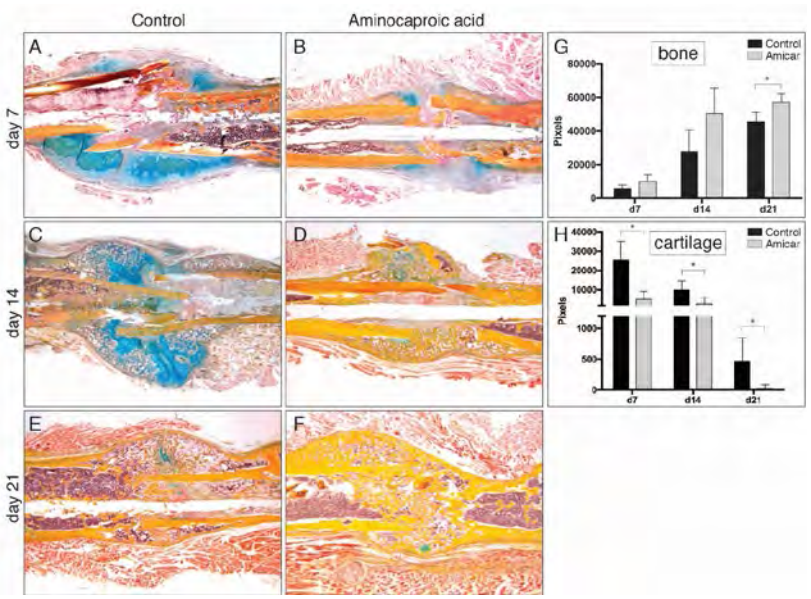
Purpose: We tested if Aminocaproic acid (AA) enhances appendicular bone healing and the mechanism of action of AA on osteoprogenitor cells (OPCs) during bone regeneration.

Methods: Bone marrow-derived OPCs were treated with varying concentrations of aminocaproic acid or control media. Cell proliferation and differentiation were assessed with standard tests. For the in vivo experiments, adult C57/BL6 mice received AA 30 minutes prior to fracture surgery and 30 minutes after surgery. A femur fracture model was utilized to assess bone formation rate, callus volume, proliferation, differentiation, and remodeling in vivo. Mice were euthanized at several days postinjury. A monocortical tibial defect model was used to study intramembranous ossification.

Results: At all examined time points, AA treatment resulted in a smaller cartilaginous soft callus, but larger bony hard callus, pointing toward an effect of AA on cell fate decisions of OPCs during fracture repair (Fig. 1). Next, we examined whether AA induces a switch from chondrogenesis to osteogenesis. We utilized a model of intramembranous bone formation to test this hypothesis. AA demonstrated a smaller bony callus than control animals. Transplantation experiments of blood clots from AA treated and control animals onto periosteal injury confirmed that AA modulated the cell fate decision from chondrogenesis to osteogenesis during fracture repair.

Conclusion: These experiments demonstrate that AA treatment during fracture healing leads to a change in cell fate of periosteal osteoprogenitor cells, with a predominance of osteogenic differentiation, resulting in a larger overall callus.



Δ OTA Grant

See pages 401 - 442 for financial disclosure information.

Negative Effects of Age-Related Chronic Inflammation on Skeletal Stem Cells

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Purpose: Osteoprogenitor cells (OPCs) are not resistant to the aging process. We hypothesize that age-related chronic inflammation contributes to a decline in the osteogenic capacity of OPCs.

Methods: Young, 12-week-old and aged, 52-week-old C57BL/6J mice were used. Aged animals were randomly distributed into control and treatment groups (n = 5 each). Animals in the control group received regular drinking water, while animals in the treatment group received sodium salicylate water for 8 weeks. The inflammatory status of the 3 groups was assessed using a multiplex platform screening for pro- and anti-inflammatory cytokines. FACS (fluorescence-activated cell sorting) was employed to identify the effect of chronic low-level inflammation on OPC number. Proliferation and osteogenic differentiation were assessed in vitro. Two-tailed Student t tests and Mann-Whitney U test were used to determine significant differences between data sets. Significance was attained at $P < 0.05$.

Results: First, we confirmed the presence of inflamm-aging in aged mice using multiplex analysis, and showed that the process is reversible by NSAID (nonsteroidal anti-inflammatory drug) treatment. Next, we aimed at understanding how aging effects OPC number using flow cytometry, which revealed that OPCs made up 0.38% and 0.017% of cells from young and aged mice, respectively. Next, we assessed whether OPC frequency changes as a result of suppressed inflamm-aging. Mesenchymal stem cells (MSCs) from 3, 12, and 12-month-old NSAID-treated animals were subjected to flow cytometry. OPC frequency declined with aging; however, after an 8-week course of NSAID treatment, we noticed a 2-fold increase in OPCs. We then aimed at testing whether NSAID treatment of aged mice resulted in a restoration of the osteogenic potential of the OPCs. Quantitative real-time polymerase chain reaction of the MSCs from NSAID-treated mice showed an increase in osteogenic gene expression compared to untreated aged mice. To further characterize this increase in osteogenic potential, we analyzed MSCs in vitro after treating them with osteogenic differentiation media. Mineralization assays and expression analysis showed decreased osteogenesis of aged cells, while treatment with sodium salicylate recovered this decline and resulted in restoration of the osteogenic potential.

Conclusion: These experiments demonstrate for the first time that age-related chronic inflammation is responsible for the decreased proliferative and osteogenic potential of aged OPCs and that this process is reversible by anti-inflammatory treatment.

Effect of Nifedipine and Ketotifen on Joint Capsule Cell Based Collagen Gel Contraction

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Purpose: Previous studies have shown that the calcium channel blocker Nifedipine (NF) and the mast cell stabilizer Ketotifen Fumarate (KF) may be used to manipulate the myofibroblast-mast cell-neuropeptide (MMN) axis that underlies joint capsule fibrosis in posttraumatic contractures. We tested our hypothesis that joint capsule (JC) cell-mediated collagen gel contraction will be decreased more when KF and NF are combined compared to either compound in isolation.

Methods: Posterior JCs from the contracture knee of 6 adult New Zealand white rabbits were harvested and transferred to a collagen gel assay using previously described methods. The gels were treated with assorted combinations of human mast cells (HMCs) 0 or 2.5×10^5, KF, and NF. KF was added at a concentration of 10^{-6} prior to gel casting overnight and NF was added at concentrations of 10^{-4}, 10^{-6}, 10^{-8}, and 10^{-10} to the JC cell/collagen gel mixture. After a 12-hour initial culture, the gels were released and photographed at 0-72 hours post-release. The contraction of collagen gels was measured and the area of the gel calculated using Image J image processing system. The gel contraction was expressed as a percentage of the gel diameter at 0 hours. Statistical comparisons used a 2-way (treatment, time) analysis of variance with a post-hoc Tukey test. Significance was set at $P \leq 0.05$.

Results: Collagen gel contraction increased significantly over time 6 hours postrelease and beyond. NF inhibited the contraction of a JC/collagen gel in a dose-dependent manner with statistically significant decreases when compared to controls at concentrations of 10^{-4} to 10^{-8}. The addition of mast cells partially reverses the inhibitory effect of NF. Ketotifen had no effect on the gel contraction if HMCs were not present. However, when KF was added to HMC and NF, KF enhanced the inhibiting effects of NF on the JC at concentrations of 10^{-4} to 10^{-8}.

Conclusion: Nifedipine resulted in a dose-dependent inhibition of JC (myofibroblast-mediated) collagen gel contraction. Ketotifen has no direct effect on the JC. In the current study it was demonstrated that mast cells must be present in order for KF and NF to have additive inhibitory effects. It appears that NF works directly on the JC while KF modifies JC gel contraction indirectly through its effects on the mast cell in this in vitro model of joint contractures. These results add to the growing body of evidence that drugs such as KF and NF can manipulate the MMN axis to control the severity of posttraumatic joint contractures and may lead to new safe and cost-effective treatment options.

See pages 401 - 442 for financial disclosure information.

Reduction in Angiogenic Support is the Primary Defect of Mesenchymal Stromal Cells Resident at the Site of Long Bone Nonunion

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Purpose: The underlying biological mechanisms that contribute to atrophic long bone nonunion are poorly understood. Mesenchymal stromal cells (MSCs) are widely accepted as key contributors to new bone formation and are also recognized as important mediators of blood vessel formation. This study examines the role of MSCs in tissue formation at the site of long bone nonunion. By comparing this tissue to induced periosteum, a highly osteogenic tissue rich in MSCs, and examining MSCs isolated from both nonunion and induced periosteum, we hope to gain new insights into disease pathogenesis.

Methods: Tissue and MSCs from the site of nonunion (n = 20) compared to induced periosteum (n = 15) and MSCs harvested from iliac crest bone marrow aspirates (n = 8). MSC colony and differentiation assays were used to assess MSC content and differentiation capacity. Flow cytometry and histological analysis was used to assess differences in overall cell content and vasculature between nonunion and induced periosteum. Real-time polymerase chain reaction was used to detect differences between expanded MSCs isolated from nonunion, induced periosteum, and bone marrow.

Results: Nonunion tissue was a rich source of MSCs that had osteogenic and chondrogenic potential comparable to bone marrow-derived MSCs. Compared to induced periosteum, nonunion tissue contained a 2.8-fold greater proportion of pericytes ($P = 0.036$), 3.3-fold more endothelial cells ($P = 0.016$), and 3.3-fold fewer lymphocytes ($P = 0.007$). Histological examination showed that blood vessels were 2.4-fold more numerous ($P = 0.001$) but had 2.9-fold smaller median luminal area ($P = 0.046$) in nonunion compared to induced membrane tissue. Transcript analysis revealed altered expression of several transcripts with primarily angiogenic roles, including FLT1, PTN, and ANGPTL4.

Conclusion: Nonunion tissue contains MSCs that do not display any impairment of in vitro differentiation capacity. The primary difference between nonunion and induced periosteum seems to be related to the vascular network, possibly due to altered expression of several angiogenic regulatory genes in nonunion-derived MSCs. We suggest that deficiency in angiogenic support rather than differentiation capacity is the primary defect in nonunion-derived MSCs.

An Evaluation of Bone Marrow Aspirate Concentrate in Osteointegration of Fresh Osteochondral Allografts

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Purpose: Bone healing is essential for success with fresh osteochondral allograft (OCA) transplants. Success rates are good (71% to 85% 10-year survival), but failure occurs from chondrocyte death or failure of bone integration. This project evaluates enhanced OCA bone healing using bone marrow aspirate concentrate (BMC). BMC contains osteoprogenitor cells and osteoinductive proteins that may accelerate OCA integration. The in vitro study compares saline control with platelet-rich plasma (PRP) and BMC in explants. The in vivo study compares radiographic integration of large femoral condyle OCAs with or without BMC. Our hypothesis is that BMC will enhance OCA bone healing.

Methods: With IACUC (Institutional Animal Care and Use Committee) approval, BMC and PRP were processed from dogs using commercially available systems. OCAs (n = 36) were obtained from femoral condyles immediately after euthanasia. On day 21 of preservation, grafts were either lavaged with saline or soaked either in PRP or BMC. OCAs were cultured for 7 or 14 days and evaluated for cell osteoprogenitor colonization and osteoinductive proteins. With IRB approval, patients' postoperative radiographs were assessed for graft incorporation and degree of sclerosis 6 weeks, 3 months, and 6 months following OCA transplantation with (n = 23) or without BMC (n = 16). Integration was evaluated by an independent musculoskeletal radiologist blinded to treatment.

Results: All BMC OCAs had viable osteoprogenitor cells distributed throughout the bone at 7 and 14 days. Viable cells were not observed in OCA bone of PRP or control OCAs at either time point. Osteoinductive proteins were eluted from PRP and BMC OCAs, with BMC having higher levels. In the clinical study, BMC OCAs had significantly ($P < 0.03$) higher graft integration at 6 weeks, 3 months, and 6 months after surgery. Graft sclerosis was significantly ($P < 0.017$) less in the BMC group at 6 weeks and 3 months post surgery.

Conclusion: OCAs treated with BMC had significantly more osteoprogenitor cells and osteoinductive proteins when compared to PRP or saline controls. Treatment of large OCAs with BMC led to more rapid osseous integration at all time points and less sclerosis during early healing compared with controls. BMC appears to have significant beneficial effects on osseous integration of OCAs via osteoprogenitor cells and osteoinductive proteins.

See pages 401 - 442 for financial disclosure information.

Femoral Neck Exposure for the Smith-Petersen Versus the Watson-Jones Approach

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Purpose: The purpose of this study was to evaluate and compare the surgical exposure provided by the Smith-Petersen (SP) and Watson-Jones (WJ) approaches.

Methods: Ten fresh-frozen pelvi underwent standardized SP and WJ approaches. Exposure was measured using calibrated digital photographs from the surgeon's viewpoint with specialized software (Figure 1). SP approaches were evaluated before and after rectus tenotomy (RT). The ability to visualize and palpate relevant anatomic structures (labrum, head, subcapital neck, basicervical neck, medial neck, greater trochanter, and lesser trochanter) was assessed.

Results: The SP approach exposed greater femoral neck than the WJ approach, providing 2.4 cm^2 and 3.3 cm^2 additional exposure with or without RT, respectively. Age, body mass index, height, and gender were not predictors of exposure. The labrum, femoral head, subcapital and basicervical neck, and greater trochanter were reliably visible and palpable in all approaches. The lesser trochanter was visible in 2 and palpable in all SP approaches, but neither visible nor palpable in all WJ approaches. The medial neck was visible and palpable in all SP approaches, while only visible in 1 and palpable in 8 WJ approaches.

Conclusion: An exposure that facilitates reduction and fixation of femoral neck fractures is critical to management. The SP approach, with or without RT, provides superior exposure to the femoral neck and clinically relevant anatomic landmarks.

a b c

Figure 1. Examples of Smith-Petersen without (a) and with (b) rectus femoris tenotomy, as well as the Watson Jones approach (c). Photographs are taken from the surgeon's perspective and retractor placement is standardized. Rulers are included at the level of the surgical field for calibration. Area (in cm^2) was measured with specialized software (Image J, NIH, Bethesda MD).

Δ The Effect of Smoking Cessation on Serum Biomarkers of Fracture Healing

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Purpose: Substantial information exists demonstrating the impact of smoking on wound healing, infection, and other outcomes following orthopaedic surgery. Little data exist demonstrating the effect of smoking and smoking cessation on inflammatory cytokines following fracture fixation. Our study uses a murine model to investigate the impact of smoking, and timing of cessation, on the regulation of vascular endothelial growth factor (VEGF) and transforming growth factor-beta (TGF-ß).

Methods: Our study incubated 70 mice for 4 weeks in a smoking chamber with 10 negative controls. These mice were divided into groups, with smoking cessation at 8, 6, 4, 2, and 1 week prior to fracture creation as well as at the time of fracture. A femur fracture was created and stabilized using a novel intramedullary fixation system. Blood was drawn from the mice during smoking, 2 weeks after fracture creation and 4 weeks after fracture creation. These blood samples were analyzed via ELISAs (enzyme-linked immunosorbent assays) for concentrations of VEGF and TGF-ß, and compared to continuous smoking, and smoke naïve controls. T tests were used to analyze the effect of smoking on VEGF and TGF-ß and linear regression was used to evaluate the effect timing of cessation on VEGF and TGF-ß.

Results: At 4 weeks postoperatively, the average VEGF level was significantly different between treatment groups ($P < 0.0001$). For all smoke-exposed mice, mean VEGF level was 93.733 pg/mL while the mean of non-smoke-exposed mice was 43.113 pg/mL ($P < 0.001$). Additionally, when compared to the treatment group at 4 weeks, the mean VGEF of mice that smoked continuously (48.276 pg/mL) and mice that never smoked (43.211 pg/mL) were both lower than groups that stopped smoking prior to fracture (101.90 pg/mL) ($P < .001$). At 2 weeks postoperatively, there was a significant difference between treatment groups ($P = 0.0309$), with TGF-ß higher in the groups with fewer weeks cessation; by 4 weeks postoperatively, TGF-ß was no different between groups.

Conclusion: Our study demonstrates that at 4 weeks postoperatively, mice that have started smoking, but stop prior to fracture creation, have a higher VEGF level than mice that smoke continuously or mice that never smoke. VEGF is a key cytokine involved in angiogenesis that contributes to fracture healing, and it appears that smoking cessation upregulates its production, while continuous smoking does not. Additionally, our data show that TGF-ß, an inflammatory cytokine, is upregulated by shorter durations of smoking cessation 2 weeks postfracture.

Δ OTA Grant

See pages 401 - 442 for financial disclosure information.

Reliability of Proxy-Reported PROMIS Physical Function and Pain Interference to Measure Outcomes in Elderly Patients Following Musculoskeletal Injury

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Purpose: Patient Reported Outcomes Measurement Information System (PROMIS) instruments are useful to evaluate health status, but their use can be challenging for some vulnerable elderly patients, requiring aid from their proxies. The goal of this study is to compare elderly patients and their proxies' answers to PROMIS Physical Function and Pain Interference Computer Adaptive Test (PROMIS PF and PI CAT) for the evaluation of patients' outcomes following musculoskeletal injury. Additionally, we sought to correlate patients' reported PF with the Timed Up-and-Go test (TUG).

Methods: We performed a prospective cohort study of 273 ambulatory patients, aged 65 years or older, and their proxies, during their recovery following injury, at 2 Level I trauma centers. PROMIS PF and PI, TUG, and FRAIL scale were performed. The correlation of PROMIS scores between patients and proxies, and also with TUG score, was assessed using Spearman rank correlation. The Bland-Altman analysis was used to check agreement and bias. Subgroup comparison was tested using probit transformations.

Results: Patients' mean age was 75.7, SD 7.5 (62.2, SD 13.8 for proxies), 66.7% females, 57.1% married, and 34% with femoral fractures. There was a significant correlation and agreement of PROMIS PF and PI scores between patients and proxies (Spearman's rho for both PF and PI = 0.73), although proxies tended to overestimate the interference of pain on patient's performance (mean difference: -1.7, P <0.001). The correlation was significantly stronger in non-frail patients and in those with faster TUG scores. There was also a correlation between patients' PROMIS PF and TUG test (Spearman's rho = -0.58).

Conclusion: Proxies are good informants of the physical function of ambulatory elderly patients, as evaluated by the PROMIS PF instrument, following musculoskeletal injury, although they tend to slightly overestimate pain interference. The use of proxy-reported patient-reported outcomes might better characterize functional impairment and pain in a vulnerable patient population and could decrease selection bias in outcomes research.

Overprescription of Opioids at Discharge in Patients After Fracture Surgery

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Purpose: As part of a quality improvement project, we evaluated our prescriptions of opioid medication at discharge after fracture surgery. Our specific goals were to examine if there was a correlation of the amount of opioids prescribed at discharge (d/c) with actual opioid use in the hospital or with the type of surgical procedure performed.

Methods: A consecutive series of patients who had fracture surgery, were admitted for at least 24 hours, and were discharged to home were included in the analysis. Patients who went to another facility were excluded. All medications were recorded in morphine milligram equivalents (MME). We compared the total opioids given to each patient during the last 24 hours of their stay with the amount prescribed at d/c. Overprescription was defined as cases in which no opioid medication was administered within 24 hour of d/c, but opioids were prescribed at d/c.

Results: We analyzed the records of 355 patients (216 M, 139 F) average age 42 years (range, 18-90) with an average body mass index of 29 kg/m^2 (range, 16-54) who fit our criteria. The average length of stay was 4.1 days (range, 1.1-50). The average procedure lasted 88 We analyzed the records of 355 patients (216 M, 139 F) average age 42 years (range, 18-90) with an average body mass index of 29 kg/m2 (range, 16-54) who fit our criteria. The average length of stay was 4.1 days (range, 1.1-50). The average procedure lasted 88 minutes (range, 6-359). The 2 most common were ORIF (open reduction and internal fixation) of the ankle and of the tibial plateau. There was a wide range of both opioid use in oral morphine mg equivalents over the 24 hours prior to d/c (average 80, range 0-272) and the amount of medication prescribed at d/c (mean 441, range 0- 4050). There was a only a weak correlation between the amount of opioids used by patients in the 24 hours prior to d/c with the prescription amounts given at d/c (Pearson's correlation = 0.16, P <0.05). Opioids were prescribed for 69% of patients who used no opioids for ≥24 hours prior to d/c. The relationship between inpatient opioid requirement and prescription at d/c was examined based on type of surgery. Average opioid consumption by procedure varied from 67 to 96 MME. Prescriptions at discharge had a wider range of 331 to 705 and averaged 439 MME. Neither the presumed severity of the procedure nor the opioid use prior to discharge correlated with the prescription given at discharge (Pearson's correlation = -0.13, P = 0.66).

Conclusion: We found that the amount of opioids prescribed at discharge were neither patient-specific nor procedure-specific in a series of patients admitted to the hospital for >24 hours after fracture surgery. Patients requiring more opioids during admission were not prescribed more opioids at discharge, while 69% of those who did not require any opioids for 24 hours or more predischarge were prescribed opioids.

See pages 401 - 442 for financial disclosure information.

Prescription Reporting with Immediate Medication Utilization Mapping (PRIMUM): Impact of an Alert on Controlled Substance Prescribing

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Purpose: Prescription narcotic abuse has reached alarming numbers. Specifically, orthopaedic trauma patients are at risk given the amount and duration of opioids given post-injury, previous histories that heighten risk, and lack of coordination between prescribers. To address this epidemic, integrated clinical decision support within the electronic medical record (EMR) to impact prescribing behavior was developed and tested.

Methods: A multidisciplinary expert panel convened to address opioid prescribing. A central EMR is utilized in 19 hospitals and emergency departments (EDs), 450+ outpatient clinics and urgent care facilities. The team identified the following risk factors for misuse, abuse, or diversion of opioids or benzos: early refill; 2+ visits to ED/urgent care with onsite opioid treatment within 30 days, 3+ prescriptions for opioids/benzos within 30 days, previous opioid/benzo overdose, and positive toxicology screen in the EMR. Risk factors were built as triggers for a rule that powers a prescriber-facing alert at the point of care. Prescribers may continue/cancel the prescription upon receiving the alert. Baseline data were collected by running the alert "silently"; 6 months of live data were collected.

Results: During the analysis period, our system had over 5 million patient encounters; a prescription for an opioid or benzo was initiated in 389,583 (8%). An alert was triggered in 23% of these encounters, with "early refill" being the most prevalent trigger (64%). For encounters with opioid prescriptions initiated (n = 300,912), the alert was triggered in 76,154 (25%), of which 14% were cancelled (n = 10,382). For encounters with prescriptions for benzodiazepines initiated (n = 102,804), the alert was triggered in 23,063 (22%), of which 24% were cancelled (n = 5409). Specifically, orthopaedic trauma surgeons at our Level I trauma center received alerts in 36% of prescribing encounters and canceled 8%.

Conclusion: Our goal is to integrate information to support clinical decision making to increase patient safety and decrease subjectivity when assessing risk for prescription drug misuse or abuse. There are legitimate medical uses for these medications; the desired outcome is not always a cancellation. Risk information is useful to the prescriber, as indicated by the number of prescriptions cancelled. Finally, this platform lays the groundwork for further clinical decision support incorporating evidence-based prescribing guidelines, and meeting emerging requirements to check drug monitoring programs.

See pages 401 - 442 for financial disclosure information.

Hemorrhage Control and Transfusion Requirements of Pelvic Ring Fractures Attending a Major Trauma Center for Emergency and Definitive Care: Does Early Aggressive Resuscitation Influence Mortality at 1 Year?

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Purpose: Pelvic ring injuries are associated with significant hemorrhage. There have been substantial improvements in trauma management and treatment of major hemorrhage in recent years. Patients are now receiving pelvic binder application on scene with a systematic approach to resuscitation, including tranexamic acid. The aim of this study was to review the mortality and blood transfusion requirements of all surgically treated pelvic ring disruptions from one major trauma center over a 3-year period, to assess the impact of this protocol.

Methods: All patients transferred to a major trauma center suffering pelvic ring or combined pelvic ring and acetabular injuries, following blunt trauma, from 2013 to 2015 inclusive were retrospectively assessed. Mortality, blood and blood product requirements, and hemorrhage control treatments (angiographic embolization and pelvic packing) were reviewed.

Results: 257 patients underwent surgery for pelvic and acetabular fractures during the study period. 132 patients had pelvic ring fixation. Data were complete for all patients. Unstable pelvic ring injuries have higher transfusion requirements, with anterior posterior compression (APC) 3 needing the highest mean volume of transfusion (10.7 units). The 30-day and 1-year mortality was 5%, transfusion was required in 40%, and only the more severe fractures (APC 3, lateral compression [LC] 3, and combined pelvic and acetabular injuries) had a mean transfusion greater than 4 units. 15% of patients were treated with massive hemorrhage protocol with a mean transfusion of 15.7 units. 6% (8 patients) had emergency application of an external fixator and all but one of these also had pelvic packing. Six patients had angiographic embolization, three of these after initial external fixator and pelvic packing.

Conclusion: Recent changes in trauma management have led to a reduction in mortality compared with historical literature. APC 3 fractures remain the most vulnerable group of patients with other unstable fracture patterns also requiring significant transfusions. 11% of patients with unstable pelvic ring injuries have either an external fixator and pelvic packing or angiographic embolization as part of their initial resuscitation.

Native Hip Survival and Long-Term Patient-Reported Outcomes following Acetabular Fracture

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Purpose: The aim of this study was to report long-term native hip joint survival following acetabular fracture and validated patient-reported outcome measures (PROMs).

Methods: 523 consecutive patients with acetabular fractures from 1988-2010 were included. Mean age was 51 years (range, 14-100) and 356 were male (68%). Management included: open reduction and interval fixation (ORIF) in 210 displaced fractures, 4 acute total hip arthroplasties (THAs), and nonoperative management in 209 undisplaced fractures and in 49 displaced/unreconstructable fractures in the elderly. PROMs (OHS [Oxford Hip Score], iHOT [International Hip Outcome Tool], UCLA) were collected at mean 13.2 years (range, 7.9-28.8) when radiographic review and Kaplan Meier survival analyses were also performed.

Results: 61 patients (12%) underwent late THA at mean 7.5 ± 7.6 years, 174 (33%) had died, and 85 (16%) were lost. With end-point THA, 10-year survival was 80.8% (95% confidence interval [CI] 74.5-87.1) after ORIF and 95.4% (92.1-98.7) following nonoperatively managed undisplaced fractures (P <0.001). With severe posttraumatic osteoarthritis (PTOA) or THA as the end point 10-year survival was 79.3% (72.8 to 85.8) and 95.4 (92.1 to 98.7), respectively (P <0.001). PROMs were significantly better in nonoperatively managed undisplaced fractures compared to ORIF: OHS (40.2 ± 12.1 vs 34.8 ± 13.7, P = 0.002); iHOT (78.0 ± 25.0 vs 66.1 ± 30.3, P = 0.01), and improvement in UCLA score (-0.9 ± 2.0 vs -2.2 ± 2.5, P = 0.001). Age was the only significant predictor of outcome following ORIF. Comparing patients <45 and those ≥45 years, OHS (38.4 ± 13.3 vs 28.7 ± 12.3) and iHOT scores (72.6 ± 28.8 vs 55.0 ± 29.9) were significantly better than in patients <45 years (P <0.001) as was 10-year survival: 86.2% (78.8 to 93.5) compared to 61.4 (48.4 to 74.3) (P = 0.015). Letournel classification, hip dislocation, surgical approach, sciatic nerve palsy, and associated fractures were not significant predictors of outcome or survival after ORIF. Following late THA, mean OHS was 35.3 ± 13.0. UCLA activity score fell from median 8 to 5 following ORIF (P <0.001), but 37% returned to preinjury levels. Median UCLA score was unchanged in nonoperatively managed undisplaced fractures. Normal hip function (OHS 100%; iHOT>95%) was reported in 13% after ORIF and 33% of nonoperative undisplaced fractures.

Conclusion: The need for ORIF in displaced acetabular fractures reduces native hip survival significantly compared to nonoperatively managed undisplaced fractures, especially in patients >45 years where long-term patient-reported outcomes are also poorer.

See pages 401 - 442 for financial disclosure information.

Reduced Survival for Uncemented Compared to Cemented Total Hip Arthroplasty after Failed Open Reduction and Internal Fixation for Acetabular Fractures

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Purpose: Posttraumatic arthritis and osteonecrosis of the femoral head are common complications after operatively treated acetabular fractures. This may cause severe disabilities for the patient, necessitating a total hip arthroplasty. Even though an arthroplasty may provide good symptomatic relief, the long-term results are more uncertain and no consensus exists according to preferred prosthetic designs. With this cohort study, we aimed to investigate the medium to long-term arthroplasty survival and clinical results of total hip arthroplasty after operatively treated acetabular fractures.

Methods: We included 52 patients treated with a secondary total hip arthroplasty (THA) at a median of 2.4 (range, 0.1-14.1) years after an operatively treated acetabular fracture. The median age was 54 years (range, 11-82). Cemented arthroplasty was used for 33 patients, 10 patients had an uncemented arthroplasty, and 9 patients received a hybrid arthroplasty. Average follow-up was 8.0 (SD 5.0) years. A standard Kaplan-Meier survival analysis with censoring was done. Differences in survivorship between groups were analyzed with the log-rank test. Cox-regression was applied to identify negative predictors for survival and estimate hazard ratios. For the clinical follow-up, all patients with complete data on Harris hip score (HHS), EQ-5D, and hip disability and osteoarthritis outcome score (HOOS score), at a minimum of 2 years after THA, were included. These 45 patients with complete data were followed for a median of 7.7 (range, 2-21) years.

Results: The overall 10-year revision free survival for any cause was 79% (95% confidence interval [CI] 62%-89%). We found that uncemented THAs had a statistically significant worse survival of 57% (95% CI 21%-81%) estimated at 10 years (P = 0.005). Cemented THA had an estimated 10-year survival of 80% (95% CI 56%-91%), and hybrid prosthesis had 100% 10-year survival. Arthroplasties performed at a center without a pelvic fracture service also had a significantly worse 10-year survival of 51%. Cox regression showed similar results. Of the 45 patients with clinical data, 39 patients had a complete set of HHS pre- and post-THA, with a mean follow-up of 8.1 (SD 5.5) years. The average HHS increased from 53 (SD 10) prior to THA to 82 (SD 16) at the latest follow-up.

Conclusion: Total hip arthroplasty secondary to an operatively treated acetabular fracture provides good symptomatic relief. These patients are, however, complex cases and are probably best treated at specialist centers with both pelvic trauma surgeons and arthroplasty surgeons proficient in complex revisions present.

Navigated Screw Osteosynthesis for Pelvic Fractures Using A Hybrid-Operating Room
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Purpose: Sacroiliac (SI) screw fixation is the standard treatment for fractures of the dorsal pelvic ring. Intraoperative 3-dimensional (3D) navigation can be an advantage for placement of screws especially in dysmorphic sacra. Osteoporotic sacral and acetabular fractures are becoming a major concern in the aging population. Minimally invasive treatment options are needed to ensure minor surgical trauma and early mobilization with full weight bearing.

Methods: In the hybrid operating room at the University of Ulm (Germany), a 3D flat-panel detector is fixed on a robotic arm and linked to a navigation system. All SI screws, navigated and nonnavigated, and all navigated acetabular screw fixations performed in the hybrid operating room in 2016 were included.

Results: 58 sacroiliac screws were implanted in 47 patients (13 male, 34 female). 22 patients received transiliac transsacral screws, stabilizing the entire sacrum and both SI joints with a single screw. In 23 patients conventional SI screws were implanted stabilizing only 1 SI joint. 2 patients received both screw types. For 2 patients no navigation was used, because of a malfunction of the navigation software. 27 patients (24 women, mean age 77 years) with sacral fractures had no adequate trauma and were classified as insufficiency fractures. 18 of these patients got transiliac transsacral screws. Mean surgical time for navigated SI screw fixation was 36.9 minutes (SD 10.1). There was no neurological complication or return to surgery because of screw malplacement. One navigated conventional SI-screw had to be removed after 4 months because of loosening in an elderly patient with an insufficiency fracture. In 4 patients with osteoporotic or mildly displaced acetabular fractures navigated, minimally invasive screw fixation was performed. 2 patients (age 77 and 72 years), who did not have an adequate trauma, were allowed to start full weight bearing after surgery. No screw loosening, infection or neurological, damage could be seen in the short aftercare interval.

Conclusion: Navigated SI and acetabular screw placement is a safe and efficient surgical technique in pelvic trauma. With a hybrid operating room a 3D scan of the entire pelvis in an excellent image quality can be obtained. This is an advantage in pelvic screw fixation especially for transsacral transiliac and acetabular screws. They seem to be a good treatment method ensuring early mobilization in elderly patients. No screw loosening of transsacral, transiliac, or acetabular screws could be seen.

See pages 401 - 442 for financial disclosure information.

An Algorithm Can Predict Blood Product Transfusion Requirements in First 24 Hours and 30-day Survival After Pelvic Fracture: 5-year Series of 589 Patients

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Purpose: Patients with pelvic fractures are at high risk of mortality and long-term morbidity. The fracture is just part of the injury profile. Our purpose is to identify specific factors, investigate their relative contributions and propose a "red alert" algorithm to predict mortality and blood transfusion requirements.

Method: All pelvis fractures in our center from 2012 to 2017 were investigated. Data included ISS, GCS, injury mechanism, other injuries, 30-day survival and blood product use. Fractures were classified by two fellowship-trained surgeons. Regression models investigated predictors of 30-day survival and blood product usage.

Results: 589 patients had pelvic fractures, male 57% female 43%; median age 48(5-100). Injury mechanism was RTA 52%, fall>2m 28%, fall<2m 16%, other 4%. Fracture type was A(15%), B1(6%), B2(65%), B3(7%) and C(7%). Mean ISS was 23(+/-15, range 4-75) and varied with fracture type: ISS was significantly higher in C than non-C fractures (p=0.000). Mean GCS did not differ between C and non-C fractures (p=0.197). Overall 30-day survival was 95% and was worse in C (86%) than non-C fractures(93-97%), p=0.001. Multivariate logistic regression showed that 30-day survival is associated with increasing age, higher GCS, having a non-C fracture and absence of haemothorax (p=0.000). Abdominal or vessel injury, open pelvis fracture, longbone fracture, gender and injury mechanism were not significant. Linear regression showed that blood product requirement is associated with lower GCS and presence of: C-type fracture, abdominal organ injury, haemothorax, vessel injury, longbone fracture and open pelvic fracture (p <0.001). Age, gender and mechanism of injury were not significant. 30-day survival was 86% in C type and 95% in non-C fractures. This compared favorably to published results in other centers and highlighted the importance of vertically displaced injuries. The proposed algorithm for predicting 30-day survival and blood product usage in this dataset of 589 patients uses regression constants from the logistic and linear regression models.

Conclusion: The algorithm may be a valuable tool for clinicians managing pelvis trauma patients by identify high-risk patients. It may help define standards for trauma center practice. The influence of non-orthopaedic injuries on mortality and transfusion requirements highlights the benefits of multidisciplinary care.

Managing Soft Tissues in Severe Lower Limb Trauma in an Aging Population

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Purpose: With an aging population, the incidence of traumatic injuries in those aged over 65 years is increasing. As a result, strategies for dealing with these patients must be developed. At present the standard management of open tibial fractures in the UK is described by the BOAST4 guidelines (from the British Orthopaedic Association and British Association of Plastic & Aesthetic Surgeons). It is not clear to what extent these are appropriate for older patients. We describe our experience of managing elderly patients presenting with open tibial fractures to our major trauma center.

Methods: Patients were identified via prospectively collected national and departmental databases. These data were supplemented by review of the patient records and radiographs. Data collated included patient demographics, injury details, orthopaedic and plastic surgery operative details, and long-term outcomes.

Results: Between April 2013 and January 2016, 97 patients aged over 65 years were admitted with open fractures. 66 of these were open tibial fractures and these patients formed the study group. 19 patients required soft-tissue reconstruction for Gustilo and Anderson IIIB tibial fractures (age range, 67-95 years). In these patients there were 7 midshaft (AO 42), 1 proximal (AO 41), and 11 distal (AO 43) fractures. 13 patients were treated with internal fixation and 6 with circular frames. The median length of hospital stay was 33 days (range, 16-113), 50% longer than comparable patients under 65. 14 patients received locoregional flaps and 5 underwent free tissue transfer. Of the 5 patients treated with free tissue transfer, one required preoperative femoral angioplasty. There were no flap losses. Four patients had fasciocutaneous flaps, 3 tibialis anterior transposition, 2 an extensor digitorum brevis flap, 1 a hemisoleus flap, and 4 were skin grafted. All patients went on to unite and return to their premorbid weight-bearing status (4 using walking frames, 3 using sticks, and 12 walking independently).

Conclusion: Although the literature suggests a significantly higher complication rate in elderly patients with open fractures, we have demonstrated comparable rates of flap survival and bony union to those observed in younger patients. Challenges are presented in terms of patient physiology and these must be carefully managed pre- and postoperatively. These challenges are reflected in the significantly longer length of stay in comparably injured patients under the age of 65 years.

See pages 401 - 442 for financial disclosure information.

3D-Printed Titanium Cages Combined with Masquelet Technique for Reconstruction of Bone Defects

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Purpose: The purpose of this study was to use custom 3-dimensional (3D) printed titanium cages as a novel treatment strategy to manage post-traumatic segmental bone loss. The cages act as a framework for bone graft, and were used here in combination with the Masquelet induced membrane technique.

Methods: Data were collected prospectively for 8 consecutive cases. The PMMA spacer remained in place for 10-12 weeks, following the Masquelet technique. 3D-printed titanium truss cages were implanted into the defect within the Masquelet membrane, and filled with autograft/allograft prior to implantation. The length and volume of the defect, length of surgery, incidence of infection, complications, need for blood transfusion, time to weight bearing, range of knee motion, rate of union, and rate of readmission were recorded. Samples from the induced membrane and control samples from normal local fascia were harvested to investigate biological activity using RNA-Seq gene analysis. Additional samples were collected for histologic evaluation.

Results: Custom 3D-printed titanium truss cages were used in 8 patients (6 male and 2 female; mean age, 53.1 years [range, 26-73]), to reconstruct 5 femurs, 1 tibia, 1 proximal humerus, and 1 midfoot. There was a mean interval between stages of 12.7 weeks (range, 11-15). The mean segmental defect measured 9.7 cm (range, 2.2-18.4). The mean bone defect volume measured 108 cc (range, 8-239). The mean length of follow-up was 8 months (6-28 months). There were no infections and no nonunions identified. Induced membrane analysis revealed up-regulation of genes associated with initiation of fracture healing. For example, vascular endothelial growth factor (VEGF), an essential gene mediating the process of angiogenesis, was highly up-regulated relative to the control specimens. Likewise, genes responsible in osteogenesis (transforming growth factor beta [TGFβ], bone morphogenetic protein [BMP]-2, receptor activator of nuclear factor kappa-B ligand [Rankl], Osterix, interleukin [IL]-6, IL-17) were up-regulated relative to the control specimens.

Conclusion: The use of patient-specific 3D-printed titanium cages, together with the Masquelet technique, is a promising new treatment option for managing complex segmental bone loss. Placing a patient-specific custom titanium implant into the highly favorable microenvironment created by the induced membrane consistently resulted in complete osseous integration of the truss implants. This was clearly demonstrated by up-regulation of the genes involved in the inflammatory, angiogenic, and osteogenic pathways.

Management and Outcomes of the Treatment of Intracapsular Neck of Femur Fractures in Young Patients

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Purpose: Intracapsular (IC) neck of femur (NOF) fractures represent a rare injury in young patients, most commonly associated with high-energy trauma. The cornerstone of their management is anatomic reduction and stable internal fixation of the femoral neck in an attempt to salvage the femoral head. The aim of our study was to evaluate the characteristics, outcomes, and complications of patients.

Methods: Over a seven-year period all patients presenting with IC NOF less that 50 years of age were eligible to participate. Exclusion criteria were older patients, pathological fractures and patients lost to follow up.

Results: Overall, 97 patients (pts) (99 fractures) fulfilled the eligibility criteria and were included in our study. The mean age was 39.3 years (range, 19.9-50.0; SD: 8.7 years). 58 patients were male, 52 fractures involved the left side, 1 patient sustained an open injury, and 13 pts sustained associated injuries. 35 fractures were undisplaced (Garden I: 5; Garden II: 30) and 61 were displaced (Garden III: 37; Garden IV: 24). Three fractures were not classified as the initial radiographs were unavailable at the time of the analysis. As per Pauwels classification, 12 fractures were type I, 34 type II, and 50 type III. Only 23 patients had dual-energy x-ray absorptiometry (DXA) scans, 5 of which were diagnosed with osteopenia and 9 with osteoporosis. The average time from admission to operating room (OR) was 13.9 hours (range, 0.7-158.3; median: 8.9 hours; SD: 21.8), whereas the average length of stay was 8.0 days (range, 1-151 days; median: 4.3 days; SD: 15.7 days). The majority of the fractures were treated with cannulated hip screws (CHS; 64 pts). Ten fractures were treated with a Dynamic Hip Screw (DHS) alone, whereas in 25 fractures a derotation screw was used along with the DHS. The mean tip-apex distance in the patients who received a DHS was 19.44 mm (range, 10-34 mm; median: 18 mm; SD: 6.1 mm). Complications were reported in 30 pts (some pts >1 complication), including nonunion in 16, avascular necrosis (AVN) in 15, screw cut-out in 5, and deep infection in 1. 13 patients underwent a total hip replacement (THR) following failure of their fixation. The risk ratio (RR) for developing a nonunion in the background of displaced fractures was 2.72 (95% confidence interval [CI]: 0.83-8.90), whereas the RR for developing AVN in displaced fractures was 2.09 (95% CI: 0.62-7.10).

Conclusion: This study demonstrates that the incidence of complications in IC NOF fractures in young pts remains high (30%), while a significant number of these patients receive a THR because of the failure to preserve the femoral head (13.4%). Regardless of the fixation method used the patient should be informed of the risk of complications, especially nonunion and AVN) and additional procedures, while a minimum follow-up of 2 years should be considered.

See pages 401 - 442 for financial disclosure information.

Risk Factors for Fibular Nail Failure in the Management of Unstable Fractures of the Ankle Joint

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Purpose: The fibular intramedullary nail provides secure fixation, high patient-reported outcome scores, and low complication rates. However, technological developments bring new potential sources of complication and error. The purpose of this study was to review our radiographic failures to determine (1) the frequency of failure of fixation, (2) radiographic risk factors for failure, and (3) a classification of modes of failure.

Methods: We identified 333 cases over an 8-year period that were managed with a fibular nail. All had adequate preoperative, intraoperative, and postoperative radiographs for analysis, with a minimum follow-up to fracture union. Demographic data, fracture classification, and detailed radiographic parameters were recorded. Failed fixations were reviewed in detail including scrupulous assessment of radiographs and operative and clinical notes. The primary outcome measure was failure of lateral malleolar fixation requiring revision.

Results: There were 332 patients with a mean age of 64 years (range, 14-96). The majority were type 44B fractures (272 cases, 82%) and according to Lauge-Hansen 262 cases (79%) were supination-external rotation (SER) type. Syndesmosis injury was seen in 58 cases (17%). Mean radiographic follow-up was 39.5 weeks (range, 6-396 weeks). In 20 patients (6%) the construct failed prior to bone healing, requiring revision. Detailed review revealed loss of locking screw fixation in osteoporotic bone in 4 cases and surgeon error in 16. Failure to implement non-weight-bearing restrictions in cases with associated syndesmotic injury resulted in 8 of the failures. In 5 cases the final intraoperative fluoroscopy images demonstrated inadequate talar reduction or poor nail placement. In 3 cases, the transverse locking screw had simply not been secured tightly. Independent risk factors for failure were pronation-abduction type fractures ($P = 0.035$), syndesmotic injury ($P = 0.006$), poor intraoperative talar reduction ($P = 0.045$), and a proximally sited locking screw >20 mm above the plafond ($P = 0.003$).

Conclusion: Fibular intramedullary nailing offers exciting possibilities for achieving stable fixation while reducing soft-tissue complications. We have reviewed our own experience, which has resulted in the manufacturer modifying the nail design, providing interlocking screws to improve pull-out strength. Surgeons are reminded of the important technical aspects of a successful intraoperative technique and appropriate postoperative management.

Channel-Assisted Minimally Invasive Repair of Acute Achilles Tendon Rupture

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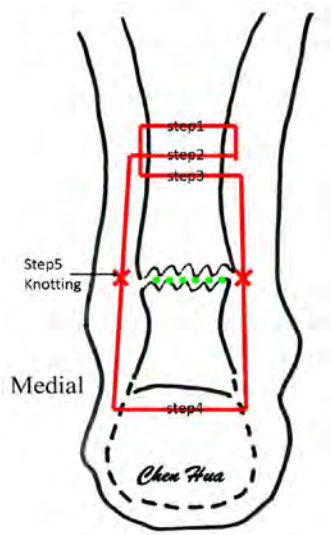
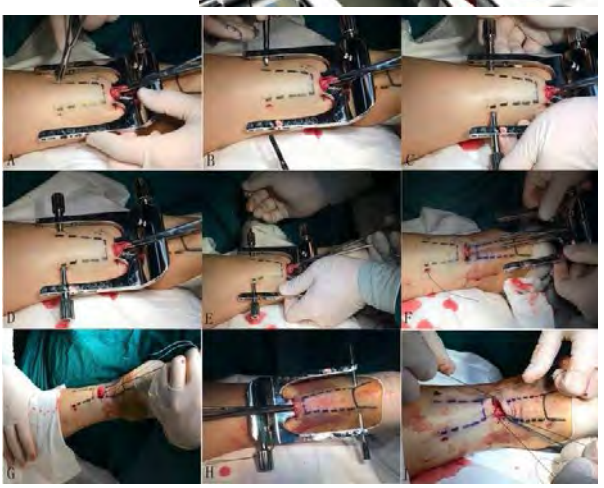
Purpose: Percutaneous (minimally invasive) suturing is a promising option for Achilles tendon (AT) repair with low rerupture and infection rates. Sural nerve lesions are the major problem to avoid with the technique. A new device was therefore designed for suturing the AT, resulting in channel-assisted minimally invasive repair (CAMIR). The purpose of this study was to compare the clinical and functional outcomes of CAMIR with traditional open techniques.

Methods: Altogether, 82 patients with AT rupture were included: 41 for CAMIR, 41 for open repair. All patients followed a standardized rehabilitation protocol. Follow-ups were at 12 and 24 months after surgery. Functional evaluation was based on the clinical American Orthopaedic Foot & Ankle Society score associated with neurologic deficit (sural nerve), calf circumference, range of motion (ROM), and isometric testing.

Results: There was no difference between groups regarding plantar flexor strength, ankle ROM, or calf circumference. CAMIR significantly decreased the operative time compared to open repair (17 vs 56 minutes, P <0.0001). Mean scar length was greater in the open repair group (10 vs 2 cm, P <0.0001). There were no wound complications in the CAMIR group but 4 in the open repair group (P <0.0001). No deep vein thrombosis, rerupture, or sural nerve injury occurred.

Conclusion: CAMIR and open repair yielded essentially identical clinical and functional outcomes. Sural nerve injuries can be minimized using CAMIR by carefully placing the suture channel with a stab incision and special trocar based on a modified Bunnell suture technique.





See pages 401 - 442 for financial disclosure information.

Clinical and Functional Outcome following Distal Tibial Fracture Treated by Circular External Fixation

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Purpose: Distal tibial fractures are notoriously difficult to treat and a lack of consensus remains on the best approach. This study examined clinical and functional outcomes in patients with fractures extending within 1 Muller square of the ankle treated definitively by Ilizarov fixation.

Methods: Between July 2011 and 2016, patients with distal tibial fractures were identified from our Ilizarov database. Fractures were classified according to the AO/OTA classification. Functional outcome data, including general measures of health-related quality of life and limb-specific scores, had been routinely collected for part of the study period. Patients in whom this had not been collected were asked to complete these by mail. Adverse events were documented according to Paley's classification of problems, obstacles, and complications. Data did not meet the assumptions for parametric analysis and therefore nonparametric methods were used.

Results: 168 patients with 169 fractures were identified, 47 (28%) were open and 107 (63%) intra-articular. 164 (97%) of the fractures united (4 nonunions, 1 amputation in a diabetic patient with an insensate limb due to peripheral neuropathy), at a median of 166.5 days (range, 104-537, interquartile range 138-203). 3 nonunions united with further treatment, 2 by Ilizarov frame and 1 by internal fixation. The final nonunion appears to be uniting in a second frame. Closed fractures united more rapidly than open (median 157 vs 183 days; $P = 0.005$) and true Pilon (43C3) fractures took longer to unite other fractures (median 157 vs 177 days; $P = 0.01$). 36% of patients encountered a problem, 11% an obstacle, and 9% a complication. Of the complications, 6 (4%) were minor, 5 (3%) major not interfering with the goals of treatment, and 5 (3%) major interfering with treatment goals. Functional outcome data were incomplete, 62% of patients overall had completed an outcome form. Overall 56% reported good or excellent ankle scores at last report, 28% fair and 16% poor. Closed, extra-articular, and non-43C3 fractures had better functional outcome scores than open, intra-articular, and 43C3 fractures, respectively. We hope to improve the completeness of this dataset. General measures of health-related quality of life revealed that these injuries continued to significantly affect patients despite good clinical outcomes.

Conclusion: This study demonstrates a high union and low serious complication rate, suggesting that external ring fixation is a safe and effective treatment for these injuries.

Medial Malleolus Fixation in Combination with Fibular Intramedullary Nailing: Are We Wasting our Time?

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Purpose: The fibular nail aims to minimize trauma to the soft-tissue envelope, particularly in high-risk patients. While the lateral malleolus appears to be crucial in controlling anatomical reduction of the talus, the role of the medial malleolus is less clear. Fixation of associated medial fractures requires generous skin incisions, periosteal stripping, and internal fixation. We have noted an increase in medial wound complications in our trauma unit. This study compare the rates of failure and complications among medial malleolar fractures, treated operatively and nonoperatively.

Methods: We identified 336 patients from our prospective trauma database that were managed for an unstable fracture dislocation with a fibular nail over an 8-year period. Isolated lateral malleolar fractures were excluded. All patients had adequate preoperative, intraoperative and postoperative radiographs. Demographic data, fracture classification, and detailed radiographic parameters were recorded. Patients completed the EQ-5D, Olerud-Molander, and Manchester/Oxford Foot Questionnaire (MOXFQ).

Results: There were 237 included patients with a mean age of 66.2 years (range, 25-96 years); 81% (n = 191) were female. There were 188 (79%) AO/OTA 44-B2/44-B3 fractures. Medial malleolus fixation was performed in 186 cases (79%). In the remaining cases the surgeon left the medial malleolus fracture without fixation. The 2 groups were well matched with respect to demographics, fracture type, and presence or absence of a posterior malleolus fracture. There was no significant difference between the 2 groups with respect to failure of fixation requiring revision surgery (P = 0.634) or loss of talar reduction postoperatively (P = 0.157). Nonunion of the medial malleolus occurred in 16 patients (31%) treated nonoperatively, compared with 22 patients (12%) undergoing fixation (P = 0.002). This was not associated with increased pain or impaired functional outcome. No patient required revision surgery for nonunion. Nine patients (5% of fixation group) required late removal of medial hardware.

Conclusion: We have demonstrated no significant difference in revision rates between fixation and nonfixation groups. We believe associated medial malleolus fractures can be treated nonoperatively in the presence of stable fibular fixation, offering decreased operative time, wound complications, and reoperation. The higher rate of radiographic medial malleolus nonunion appears to be of minimal clinical significance.

See pages 401 - 442 for financial disclosure information.

Clinical and Radiographic Outcomes of Talar Fractures

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Purpose: Talar fractures are rare injuries associated with significant morbidity and poor long-term functional outcomes. There is variability of classification systems and ongoing debate regarding definitive management. We aimed to characterize the fracture morphology and outcomes in a large consecutive series of patients.

Methods: All adult talar fractures presenting to the Edinburgh Trauma Service between 2008 and 2015 were identified from a prospective database. Fractures were classified using the Hawkins-Canale and Sneppen systems. Osteochondral "dome" type fractures were excluded. All patient records and radiographs were scrutinized for avascular necrosis (AVN), fusion procedures, and nonunion. Mechanism of injury was classified as high-energy (road-traffic accident or fall from a height >2 meters) or low-energy.

Results: 61 fractures were identified over the 7-year period, of which 6 were open fractures and 3 were bilateral. The commonest fracture pattern identified was a displaced talar neck fracture (n = 46: 8 type I, 27 type II, 6 type III, 5 type IV) followed by talar body fractures (n = 16). 35 cases were associated with multiple injuries. 34 fractures underwent operative treatment in 1 of 3 methods: anteropostererior screws, posteroanterior screws, or plates and screws. There were 5 confirmed cases of AVN, 1 case of nonunion, and 10 fusion procedures. 40 cases arose from high-energy injuries and all cases of AVN, fusion, or nonunion were seen in this group irrespective of fracture pattern. There were no cases of AVN, fusion, or nonunion in the low-energy group.

Conclusion: We present a large series of talar fractures and demonstrate that a high-energy mechanism is associated with AVN, nonunion, and the requirement for fusion. Careful initial assessment should focus on injury mechanism to identify patients at risk of a poor outcome.

Δ Validity of Utilizing the RUST Scoring System in Radiographic Evaluation of Femoral Shaft Fractures

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Purpose: Evaluation of fracture healing requires radiographic and clinical assessment. There are little data regarding radiographic evaluation of femoral shaft fractures and their healing after treatment. A scoring system was developed to assess tibial fractures using 2 radiographic views—the RUST (Radiographic Union Score for Tibial fractures) scoring system. This study aims to determine the validity of using RUST scores to evaluate femoral shaft fracture healing, and if a modified RUST score using a single AP view is valid in settings where radiographic quality is limited.

Methods: This study consisted of 321 adult patients in Tanzania who underwent intramedullary (IM) nailing for diaphyseal femur fractures. Radiographic healing was assessed at 6, 12, 26, and 52 weeks. RUST scores were assigned using defined guidelines. Additionally, a modified RUST score was utilized for patients with only one radiographic view. For data analysis, 4 RUST scoring categories were used: conventional RUST score (AP + lateral), modified RUST score, RUST of AP view, and RUST of lateral view. The modified RUST score was equal to the single-view RUST score doubled. With both views present, the modified and conventional scores were equal. Convergent validity was assessed by correlating RUST scores with the EQ-5D. Divergent validity was assessed by comparing the difference in RUST scores between patients requiring reoperation and those who did not (uncomplicated). Finally, modified RUST scores were correlated with conventional RUST scores to assess the appropriateness of utilizing the modified score.

Results: All categories of RUST scores correlated with EQ-5D values. Resultant Spearman coefficients were 0.5 or greater. Patients who required subsequent reoperation had lower RUST scores than uncomplicated patients. Scores were 4.0 versus 5.79 ($P < 0.0005$), 5.38 versus 7.35 ($P = 0.005$), and 5.30 versus 8.99 ($P < 0.0005$) at 6, 12, and 26 weeks, respectively. RUST scores were similar at 52 weeks. Modified RUST scores correlated with conventional RUST scores, with all Spearman coefficients >0.96.

Conclusion: The RUST score demonstrated excellent convergent and divergent validity in femoral shaft fractures managed with IM nailing in Tanzania. Additionally, the modified RUST score was very strongly correlated with conventional RUST scores and demonstrated equivalent validity characteristics, suggesting it may be a viable alternative in settings where orthogonal views of the fracture are not consistently available.

Δ OTA Grant

See pages 401 - 442 for financial disclosure information.

Consolidation in Femoral Fractures: A Cohort Study in Patients Exposed and Not Exposed to Bisphosphonates

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Purpose: Atypical fractures associated to prolonged consumption of bisphosphonates (BF) have characteristic radiographic patterns. For these fractures epidemiological studies found a 26% delayed or nonunion rate. The aim of our study was to compare the time to union in patients consuming BF and a control group of patients with similar demographic characteristics.

Methods: Two groups were conformed: Group 1, 34 patients with 41 fractures associated with BF consumption and Group 2, not exposed to BF, 67 patients with similar demographic characteristics. Both were treated surgically for midshaft and proximal femoral fractures. In both groups, radiographic consolidation time was evaluated. A statistical analysis of age, sex, and time to the consolidation was performed.

Results: Group 1 had an average age of 77 years and an average BF consumption of 7.5 years. The average time to consolidation was 22 weeks, requiring in 3 cases the dynamization of the implant to achieve consolidation. In Group 2, 67 patients, mean age was 79 years (P = 0.89). The mean time of consolidation was 27 weeks. No statistically significant differences between groups was found (P = 0.77). The power of the study was 0.54. The complications in this group were 3 cases of rupture of locking screws, 1 deep infection requiring a revision, and 3 cases of nail change due to delayed consolidation.

Figure 1 - Radiographic evaluation of pre and post operative BF consumption associated femoral fracture . Note the radiographic typical characteristics associated to BF consumption and the healing of the fracture with an anterograde femoral nail.

Conclusion: Our study did not show significant differences in the time of consolidation between groups. Higher rates of delayed or nonunion, as described, were not seen.

Healing of Atypical Subtrochanteric Femur Fractures after Cephalomedullary Nailing: Which Factors Predict Union?

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Purpose: The purpose of this study was to (1) determine the healing rate and time to union of atypical subtrochanteric fractures treated with cephalomedullary nailing, (2) evaluate the factors that may affect healing of these fractures, and (3) report the complications encountered after cephalomedullary nailing.

Methods: Between January 1, 2005 and December 31, 2013, 132 suspicious, atypical femur fractures associated with bisphosphonates (BPs) in patients presenting to 6 Level I trauma centers in the Asia-Pacific region were screened for enrollment. The final cohort included 42 patients with 48 displaced, atypical, BP-associated subtrochanteric femur fractures. Data were collected using a unified Case Report Form from each center. Surgical records included the operative report for the surgical procedure, reduction technique, presence of reaming and amount of over-reaming of the intramedullary canal, and the type of implant used. Radiographs taken preoperatively, in the immediate postoperative hospitalization period, and at 3-month intervals postoperatively were evaluated in the study. The primary outcome in this study was radiographic healing and healing time.

Results: The primary healing rate after cephalomedullary nailing of BP-associated subtrochanteric femur fractures was 68.7% (33 of 48 patients). Mean time to union was 10.7 months. Malalignment was determined using the differences in neck-shaft angle (the difference between the normal side and the surgically repaired side), and sagittal angulation. These all proved to be significantly correlated with failure and delayed healing time. The cut-off points for neck-shaft angle, difference in neck-shaft angle, and sagittal angulation were 125.6°, 4.4°, and 5.5°, respectively (receiver operating characteristic [ROC] curve analysis).

Conclusion: The healing rate of atypical subtrochanteric femur fractures treated with cephalomedullary nailing is lower than that previously reported for atypical femur fractures. The quality of fracture reduction proved to be the most important factor in bony union and time to union.

See pages 401 - 442 for financial disclosure information.

Δ Does the Choice of Antegrade or Retrograde Approach to Intramedullary Nailing of Diaphyseal Femur Fractures Affect Progression of Knee Range of Motion in Settings that Lack Formal Physiotherapy?

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Purpose: Intramedullary (IM) nailing of femoral shaft fractures can be accomplished via the antegrade or retrograde approach. While both are commonly used, the retrograde approach raises concern for increased knee complications, due to its insertion through the knee joint. One important postoperative outcome related to knee function is range of motion (ROM). The purpose of this study is to determine the impact that approach in IM nailing of femoral fractures has on knee ROM in low-resource settings that do not receive routine postoperative physical therapy.

Methods: Patients receiving IM nailing for femoral diaphyseal fractures were included in this study. Follow-up visits were conducted at 6, 12, 26, and 52 weeks postoperatively. The degree of knee flexion and presence of neutral extension was determined at each time point. Patients failing to reach 90° by 52-week follow-up were analyzed for difference based on approach utilized. Additionally, the population of patients failing to reach 90° of flexion by each time point was assessed.

Results: Antegrade approach had a significantly higher average degree of flexion at 6 weeks (114.21 vs 106.92, P = 0.030) and at 52 weeks (136.73 vs 133.25, P = 0.027). Flexion was similar between approaches at 12 and 26 weeks. There was a significant difference in proportion of patients achieving neutral extension at 6 weeks (96.3% antegrade vs 85.7% retrograde, P = 0.010), but the percentages were similar at all other time points. There was no difference in approach on patients achieving 90° by 52 weeks. At each subsequent time point, fewer patients below 90° of flexion eventually achieved that ROM.

Conclusion: The antegrade approach to IM nailing of femoral shaft fractures appears to have an early postoperative advantage for knee ROM over the retrograde approach, but this difference diminishes over time. Patients failing to achieve 90° early in the recovery period should be considered for intervention to prevent reduced ROM at 1 year.

Δ OTA Grant

Management and Outcomes of Periprosthetic Fractures of the Femur

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Purpose: Increasing age and numbers of primary and revision arthroplasties lead to an increase in periprosthetic fractures. Based on type and site of fracture, implant status and comorbidities various surgical strategies are available. Complex surgery and comorbidities increase morbidity and mortality associated with these injuries. Aim was to assess management, mortality rates, complications, and outcomes of periprosthetic femoral fractures.

Methods: January 2010 to June 2015, from a prospective database periprosthetic femoral fractures were identified. Patients with early fracture after revision joint replacements, previously known infected joint were excluded. Data collected included patient demographics, comorbidities, mechanism of injury, American Society of Anesthesiologists (ASA) grade, type and site of fracture, time to surgery, surgical management, postoperative rehabilitation, early complications, unplanned further surgeries, implant and patient survival. Kaplan-Meier survival analysis was performed to assess mortality rates.

Results: 109 periprosthetic femoral fractures in 108 patients during the study period. Mean age was 79 years (21-96) male to female ratio 31:77. There were fractures around hip hemiarthroplasty (12), cemented total hip replacement (THR) (36), uncemented THR (21), total knee replacement (TKR) (26), and interprosthetic femoral fractures (14). Most patients were ASA grade 3 (82 of 108). All except 1 fracture was from standing height falls. 14 were on warfarin. 8 on clopidogrel. Mean time to surgery was 3 days (1-12). Follow-up period was a mean of 2 years. Complications included 1 death on table, 4 wound hematomas that were washed out, 3 deep infections that were managed with debridement and implant retention with suppressive antibiotics as patients were not suitable for 2-stage or prolonged single-stage revision surgeries. Three plate fixations for B1 fractures around a THR failed. Of the 86 patients who went to rehabilitation unit, 38 went to assisted-living facility. Majority of the patients (79) used a walking aid in the long term. Mortality rate was 36/109. Deaths within 3 months (early deaths) were 12 (11%), within a year 29 deaths (27%). Late deaths were natural deaths or due to unrelated events.

Conclusion: Incidence of early periprosthetic fractures is higher in uncemented THR while cemented THRs have a higher incidence of late fractures. Periprosthetic femoral fractures occur in patients who often have significant medical comorbidities. Surgical intervention in general has a good outcome, but most of the patients spend time in a rehabilitation unit and do not reach their prefracture mobility status. One-year mortality is 27% in these patients.

See pages 401 - 442 for financial disclosure information.

Intramedullary Nailing for Atypical Femoral Fracture with Excessive Anterolateral Bowing

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Purpose: Intramedullary (IM) nailing is the treatment of choice for atypical femoral fractures (AFFs). However, several problems, such as iatrogenic fracture and medial gap opening, can occur during IM nailing when AFFs are associated with excessive anterolateral bowing. To overcome these problems, we have developed a new grading system for anterolateral femoral bowing and a new technique for IM nailing. The purposes of this study were (1) to introduce a new grading system and new IM nailing technique for AFF with anterolateral femoral bowing and (2) to compare the postoperative outcomes between the new technique and the conventional technique for IM nailing.

Methods: The new grading system was divided into 3 grades according to the position of the reference line at the apex of the curve of the anterolaterally bowed femur on a true AP view radiograph. The reference line is drawn from the tip of the greater trochanter to the center of the intercondylar notch. The core of the new IM nailing technique is matching the anterior curvature of the femoral nail with the anterolateral bowing of the femur when the nail passes the apex of the curvature, by rotating the nail externally. From January 2005 through March 2016, 24 female patients (30 cases) who underwent surgery for AFF with anterolateral bowing at 2 institutes were evaluated retrospectively. The postoperative outcomes (anterolateral bowing grade, anterior and lateral bowing angle, medial gap and posterior gap of the fracture site, iatrogenic fracture, and time to initial medial callus formation and bone union) were compared between the new technique (group A, 18 cases) and the conventional technique (group B, 12 cases).

Results: The interobserver and intraobserver reliability of the new grading system demonstrated an almost perfect agreement ($kappa_{inter}$ = 0.893, $kappa_{intra}$ = 0.883). There were no significant differences in the preoperative factors between two groups. The differences between the preoperative and postoperative anterior and lateral bowing angles were significantly less in group A ($p = 0.013$ for both). The medial and posterior gaps of the fracture site were also significantly less in group A ($P_{med} = 0.013$, $P_{post} = 0.022$). Iatrogenic fracture occurred only in group B, affecting 2 cases. The time to initial medial callus formation was significantly shorter in group A than in group B ($P = 0.033$).

Conclusion: Our new grading system for anterolateral femoral bowing is convenient and reliable. Furthermore, the new IM nailing technique with the current IM nail system is appropriate for the repair of AFFs with excessive anterolateral bowing.

Evolution of a Combined Orthopaedic/Orthogeriatric Hip Fracture Service in a District Hospital: Key Lessons Learned

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Purpose: Patients with hip fracture are increasing worldwide. Hip fracture care has evolved dramatically over the past 2 decades, to become more holistic and team-based. There is an increased awareness that timely, expert delivery of care can make a big difference to outcomes, complication and mortality risks. We chart our hip fracture patient service development, over the past 20 years. We aim for this to act as a guide to other departments in similar sized, non-teaching hospitals where funding and recruitment are a challenge. Our improvements have run in parallel with a number national initiatives.

Method: We have undertaken a number of prospective observational studies based around an Access database set up in 2000, following on from a paper-based dataset. The hip fracture dataset formed a key part of the department›s clinical audit, and allowed the following studies: tracking demographic and numeric changes in our hip fracture population from 1996 to 2006 the efficacy of adding an orthogeriatric team to our hip fracture service in 2006 the stratification of hip fracture patients by clinical complexity quarterly 30 day mortality rate changes over a decade from 2006 to 2015.

Results: Our number of hip fractures has increased over 3-fold in 20 years, higher than the overall national increase. We noted a 50% drop in mortality following the introduction of an orthogeriatric team in 2006, significant reductions in time to surgery and patients being medically optimized ($P < 0.01$). We mapped an improving trend over time, until 2011, when it plateaud. Our clinical complexity analysis showed wide disparities in 30-day and 1-year mortality risk between our most straightforward and most complex patients ($P < 0.0001$) and no benefit from early surgery. We noted fluctuations in mortality, with consistent seasonal quarterly mortality spikes in colder weather.

Conclusion: Positive changes can be made in an individual unit independent of national or regional initiatives, using local data. The data can show the importance of local factors not be immediately considered, such as increased patient numbers, or worsening specific patient factors and longer term local trends. Our studies confirm the benefits of a multidisciplinary team, the utility of a patient complexity score, the importance of consistent data collection and presentation of potentially uncomfortable data that may require culture change within departments, and likely gaps in the current dataset that we should address.

See pages 401 - 442 for financial disclosure information.

Δ Marked Deterioration in Living Status and Use of Aids After Operative Management of Hip Fractures in the Elderly

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Purpose: Hip fractures lead to significant morbidity and mortality in elderly patients. The associated morbidity often results in decreased mobility, a loss of independence, and an inability to perform activities of daily living. A recently completed trial evaluated the effects of sliding hip screw versus cancellous screws in 1079 patients aged 50 years or older with a femoral neck fracture. Using data from this multicenter trial, we describe how patient living status and use of aids change over the 24 months following their fracture.

Methods: We conducted a descriptive analysis to quantify patients' changes in living status and changes in the use of aids within 24 months following their femoral neck fracture. Results were reported as counts and also presented in percentage form.

Results: The majority of patients (90.41%) who were between the ages of 50 and 80 years returned to living independently 24 months following their hip fracture. Of those patients over the age of 80 years who were living independently at the time of their fracture, the majority (70.90%) also returned to living independently 24 months following their hip fracture. However, for patients over the age of 80 years who were institutionalized at the time of their fracture, the majority (87.50%) remained institutionalized over the course of their 24-month follow-up. Regardless of age, nearly all patients required a walking aid at hospital discharge. By the 24-month follow-up, the majority of patients over the age of 80 years (82.16%) and the majority of patients between the ages of 50 and 80 years who were not walking independently at the time of their fracture (72.58%) continued to use walking aids. The only patients who were not using walking aids by the 24-month follow-up visits were the majority of those between the ages of 50 to 80 years who could ambulate independently at the time of their fracture (68.35%).

Conclusion: Regardless of age, we found that the majority of patients who suffered a femoral neck fracture also experienced a loss of mobility over the 24 months following their fracture. This was especially evident in patients aged over 80. Additionally, a high proportion of elderly patients experienced a loss of independence that led to institutionalization in the 24 months following their hip fracture.

Δ OTA Grant

Analysis of Intertrochanteric Hip Fractures Failure: What Do Trauma Surgeons Agree Upon?

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Purpose: Intertrochanteric fractures (ITFs) are among the commonest pathologies treated by orthopaedic surgeons. Fixation failures are reported to occur between 5% and 16% according to established and also recent literature. However, the definition of failure, the rate of failure between different implants (ie, nails or extramedullary implants), and the causes of failure remain controversial. The aim of the study was to identify factors that are commonly identified by orthopaedic surgeons as risk factors for fixation failure following ITF.

Methods: Between 2008 and 2015 more than 3000 ITFs were operated in our center. Out of them 169 were identified as ones with significant change of fracture alignment or implant position postoperatively and were considered fixation failures. Out of them 138 sets of radiographs including preoperative, intraoperative fluoroscopic images, and immediate and late postoperative images were presented to 4 experienced (>10 years) fellowship-trained trauma surgeons as blind PowerPoint presentations, coupled with detailed study questionnaires. 100 cases had complete questionnaires filled in by all surgeons. Out of them 70 were fixed by percutenous compression plate (PCCP) and 30 by cephalomedullary nails. The surgeons were asked to fill in the details regarding AO/OTA classification, identification of posteromedial comminution, lateral wall fracture, implant preference (nail or plate), quality of reduction (by a score and specifically for the calcar), existence of a technical error, permission for postoperative weight bearing, and eventually type of failure based on 9 categories. Time frames of radiographs included preoperative, interaoperative, immediate, and late postoperative. It should be noted that intraoperative fluoroscopic images after reduction were found only in 40 patients. The Kendall tau nonparametric test was used to assess agreement between the 4 observers. With this test a nonsignificant ($P > 0.05$) value was considered as an agreeable parameter.

Results: Of all parameters the following were considered to have agreement between the surgeons: preoperative AO/OTA (31A1 to 3) classification, posteromedial communition after reduction, broken lateral wall (after reduction), implant preference, postoperative reduction quality of the calcar and the fracture, weight-bearing recommendation, and the existence of a surgical error. The observers failed to agree about the intraoperative AO/OTA classification, intraoperative reduction quality, and the type of failure observed.

Conclusion: Intraoperative decision-making in treating trochanteric fractures may be more complicated than it seems. Although significant variation among surgeons can be seen, experienced trauma surgeons do agree among crucial factors affecting surgical outcome including fracture classification, reduction quality, preferred implant, and the existence of surgical errors.

See pages 401 - 442 for financial disclosure information.

Early Clinical Experience with the SIGN Hip Construct

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Purpose: As the population ages, the developing world industrializes and more urban centers emerge, the burden of orthopaedic trauma will steadily increase. SIGN (Surgical Implant Generation Network) Fracture Care International has developed a unique intramedullary device for fixation of hip fractures in low-resource settings lacking fluoroscopy. We report the safety profile and complication rate for an early consecutive series of patients with hip fractures managed using this implant.

Methods: A database with prospectively collected data, maintained by the implant manufacturer, was used to retrospectively review the first 170 patients treated with the SIGN Hip Construct (SHC) for a proximal femur fracture from 2009 to 2014. Patients who sustained a proximal femur fracture with follow-up >12 weeks and adequate radiographs were included. Data recorded include patient demographics, time to surgery, union rate, AO/OTA classification, complications, neck-shaft angle, and clinical outcomes including painless weight bearing and knee flexion greater than 90°.

Results: Of the 170 patients managed with the SHC, 71 patients (42%) met the inclusion criteria with mean a follow-up of 39 weeks (range, 21-64). The mean patient age was 49.5 years (range, 12-91) consisting of 48 men (67%) and 23 women (33%). In terms of World Health Organization (WHO) region, 27 (38%) were from Africa, 21 (29.6%) from Eastern Mediterranean, 17 (23.9%) from Western Pacific, and 3(4.2%) each from Americas and Southeast Asia. Fractures treated included 55 (77.5%) intertrochanteric, 7 (9.9%) subtrochanteric, 4 (5.6%) femoral neck, and 5 (7%) combined type. Reduction quality was good in 35 (49%), acceptable in 19 (27%), and poor in 17 (24%). Major complications consisted of varus collapse in 6 (8.5%), nonunion or delayed union in 3 (4.2%), intra-articular screw placement in 5(7%), and infection in 3 (4.2%). The average initial postoperative neck-shaft angle was 126° (±7.3°) postoperatively and 119.3° (±11°) at final follow-up.

Conclusion: This is the first comprehensive report of a novel implant for hip fractures specifically designed for low-resource settings. The early clinical data and outcomes suggest that the SHC can be safely inserted in the absence of fluoroscopy, and facilitates early mobilization while maintaining acceptable reduction until union.

Use of Fully Threaded Cannulated Screws Decreases Femoral Neck Shortening After Fixation of Femoral Neck Fractures

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Purpose: Femoral neck fractures (FNFs) are becoming increasingly common as the population ages. Nondisplaced fractures and displaced fractures in young patients are commonly treated by fracture reduction and fixation with cancellous, parallel placed, partially threaded cannulated screws (PTS). The rationale for using this fixation technique is to enable healing by controlled fracture impaction across parallel placed screws. However, sliding implants can lead to excessive fracture collapse, resulting in femoral neck shortening (FNS), which is of a major clinical concern. FNS can cause abductor muscle weakness as well as overall limb shortening. This has been shown to be correlated with reduced quality of life as measured by patient-reported outcome measures. Recently, as a policy, our institution has moved to fixation of nondisplaced fracture with more length-stable implants, ie, fully threaded screws (FTS) in order to minimize this phenomenon. The aim of this study was to compare the femoral neck shortening in patients treated with FTS as compared with historical controls treated with PTS.

Methods: Between 2014 and 2016, 38 patients were treated with FTS (2 or 3 out of 3) for mainly nondisplaced or valgus impacted FNF. Out of them 22 were available for complete radiographic follow-up. A group of 41 patients treated previously with PTS were available as a control group. Radiographic analysis was performed using TraumaCAD (BrianLAB, Munich) to assess the FNF in 3 vectors: horizontal (x), vertical (y), and overall according to the neck-shaft angle (NSA) as previously published. All measurements were performed by 2 fellowship-trained trauma surgeons.

Results: Patients' age, sex, Garden class, and major complication rate (osteonecrosis and nonunion) were similar in the 2 patient groups. Average FNS in the x axis (abductor lever arm) was significantly smaller in the FTS group than in the PTS group (3.1 ± 3.6mm vs 7.6 ± 4.2 mm, respectively, $P < 0.01$) as well as y shortening (1.2 ± 2.6 mm vs 4.9 ± 4.2mm, $P < 0.01$) and also decreased overall z shortening (2.5 ± 3.5 mm vs 6.23 ± 4.5, $P < 0.01$). There was a tendency toward a more valgus NSA in the PTS (137 vs 134°) although it did not reach statistical significance ($P = 0.08$). When stratifying the shortening into mild (<5 mm) moderate (5-10 mm) or severe (>10 mm shortening) in all vectors, the FTS group had a significantly smaller number of patients in all categories. Screw pullout >5 mm occurred in 17 out of 41 patients in the PTS group and did not occur in the FTS group ($P < 0.01$).

Conclusion: This study proves that moving to more length-stable implants improves the radiographic results following FNF fixation using cannulated screws. A larger, prospective study including clinical outcome measurements is required to further establish the clinical benefit of using this fixation method.

See pages 401 - 442 for financial disclosure information.

Unstable Intertrochanteric Fractures: Is the Best Plate a Nail?

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Purpose: The management of Intertrochanteric hip fracture remains contentious. We aimed to determine if either sliding hip screws or cephalomedullary nails have superior outcomes for unstable intertrochanteric hip fractures.

Methods: We prospectively reviewed all unstable intertrochanteric hip fractures (AO31A2.2 to AO31A3.3) from January 2001 to December 2015 inclusive. Patient demographics, surgical details, functional scores, and 1-year mortality were assessed for 3 distinct operative procedures: sliding hip screw (SHS), SHS with trochanteric stabilization plate (SHS + TSP), and cephalomedullary nails (CMN). The data were statistically analyzed and $P < 0.05$ considered significant.

Results: We identified 3451 patients of whom 3230 had full data sets available for analysis. The mean age of 80 ± 12 years. The mean ages by implant were SHS 80.5 ± 11.6, SHS + TSP 80.5 ± 11.9, and CMN 79.0 ± 13.3, with a significant difference noted between SHS and CMN only ($P = 0.016$). A female preponderance of 3:1 was noted. Frequency of A2.2 and A2.3 fracture subtypes increased ($r = 0.377$ and $r = 0.548$, both $P < 0.001$), while a nonsignificant increasing trend in A3 subgroup ($r = 0.068$, $P = 0.423$) was observed. Modal ASA (American Society of Anesthesiologists) grade was 3, with no difference in ASA grades between groups ($P = 0.138$). SHS procedures reduced ($r = -0.903$), with a concomitant increase in SHS with TSP ($r = 0.777$) and CMNs ($r = 0.864$). Baseline functional scores were similar. No difference was seen at 12 months postoperatively ($P = 0.179$). All implants displayed functional deterioration from baseline ($P < 0.0001$). The SHS + TSP group had the longest inpatient stay (18.1 ± 14.3), versus SHS 12.5 ± 9.8 and CMN 12.6 ± 9.1 ($P < 0.001$). Revision rates were SHS 4.04%, SHS + TSP 2.53%, and CMN 2.34%, respectively ($P = 0.239$). Kaplan Meier plots for mortality at 12 months for each group was 22.6% SHS, 27.2% SHS + TSP and 18.1% CMN ($\times 2(2) = 9.165$, $P = 0.014$). Subanalysis by gender demonstrated males were at an increased risk of mortality at 12 months postoperatively.

Conclusion: Better baseline functional scores and a younger age may influence the use of CMNs. No functional benefit is conveyed at 12 months postoperatively. Males tended to be younger, with higher 12-month mortality risk compared to females, regardless of implant. The use of a CMN for treating unstable intertrochanteric fractures of the hip is associated with equivocal length of stay and lower mortality rates compared to a SHS, with or without an additional TSP.

Long-Term Patient Satisfaction and Residual Symptoms After Plate Fixation and Nonoperative Treatment for Displaced Midshaft Clavicular Fractures

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Purpose: Recent studies have shown that plate fixation reduces the risk of nonunion compared with nonoperative treatment for displaced midshaft clavicular fractures, but that shoulder function is similar and secondary operations are common after both treatments. In addition, it is of value to evaluate long-term results from the patient's point of view. The aim of this study was to evaluate long-term patient-reported satisfaction and residual symptoms after plate fixation (PF) and nonoperative treatment (NOT) for displaced midshaft clavicular fractures.

Methods: 160 adult patients with a fully displaced, midshaft clavicular fracture that had been included in a multicenter randomized controlled trial comparing PF and NOT were interviewed for a long-term follow-up survey. Outcomes were satisfaction with the received treatment, with the cosmetic result, and with the shoulder function (measured on a scale of 1 to 10), and presence of residual symptoms. Also, patients were asked if they would opt for the same treatment if they were to fracture their other clavicle.

Results: 79 patients (40 after PF, 39 after NOT) could be contacted and agreed to participate. The median follow-up was 53 months (range, 34 -79). Overall satisfaction was similar for PF and NOT (mean score ± SD: 7.7 ± 2.1 vs 6.9 ± 2.4, P = 0.12), as was satisfaction with the shoulder function (9.1 ± 2.3 vs 8.6 ± 2.6, P = 0.43). Patients were more satisfied with the cosmetic result after PF (8.2 ± 1.6 vs 6.8 ± 2.0, P = 0.002). Less than half of the patients felt that their shoulder had fully recovered (48% for PF vs 46% for NOT, P = 1) and residual symptoms were frequently present in both groups (55% for PF vs 41% for NOT, P = 0.26). After PF, 88% of patients would prefer the same treatment again, compared with 41% after NOT (P <0.001).

Conclusion: Despite the fact that residual symptoms were common after both plate fixation and nonoperative treatment, and satisfaction with the functional result was excellent in both groups, most patients would opt for surgical treatment in case of a future clavicular fracture. In order to manage patients' expectations, objective information regarding both treatment options should be provided before a shared treatment decision is made.

See pages 401 - 442 for financial disclosure information.

Proximal Humerus Reintervention After Open Reduction and Internal Fixation for Fracture: A Survivorship Analysis and Report on Patient Outcomes

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Purpose: Proximal humerus fractures represent an important fragility fracture frequently managed by orthopaedic surgeons. Recent research has focused on the optimal treatment modalities for these injuries. Open reduction and internal fixation (ORIF) of proximal humerus fractures remains a topic of debate. This study evaluates the survivorship and functional outcomes after initial fixation of patients with proximal humerus fractures.

Methods: A single center prospective database review identified 579 patients treated surgically with proximal humeral ORIF between 1996 and 2015. Inclusion criteria were: acute proximal humerus fracture treated with ORIF, age over 14 years at the time of injury, and a minimum of 2 years follow-up. Patient demographics, patient-reported outcomes, complications, and the need for additional surgery were recorded. Study end points included: revision ORIF, conversion to arthroplasty, and death. Kaplan-Meier survival analysis and Cox proportional-hazards regression were performed to assess for risk factors for failure.

Results: 337 patients met inclusion criteria. 27 patients were excluded and 238 patients had data available (77% response rate). 71 patients were deceased (30% mortality) and 3 institutionalized. Mean follow-up was 7.9 years. Average age at the time of operation was 58 years (SD 13). Fracture type by Neer classification included: 38% type 2, 28% type 3, and 34% type 4. 34 anterior fracture-dislocations and 43 posterior fracture-dislocations were included. Oxford Shoulder Score and QuickDASH (an abbreviated version of the Disabilities of the Arm, Shoulder and Hand [DASH]) scores were 32.2 and 16.9, respectively. 28% of patients underwent reintervention for any cause. Median survival time to reintervention was 76 months and 93 months for survival to arthroplasty. At a mean of 7 years post ORIF, 72% of patients remained reintervention free. Renal disease was the only significant predictor of reintervention. 11% (19 patients) required conversion to arthroplasty. Overall patient-reported shoulder satisfaction was high: mean global shoulder score of 83% (SD 18.6) at 2 years post procedure.

Conclusion: Overall, our data suggest that ORIF for proximal humerus fractures does not result in early revision or arthroplasty and survival of the procedure is the norm. Additionally, failure requiring conversion to arthroplasty or revision generally occurs late (>7 years). Furthermore, we demonstrated that a subset of patients may be at higher risk of requiring additional reoperation or revision.

Long-Term Follow-up after Implantation of a Bipolar Radial Head Prosthesis Versus Osteosynthesis to Treat Complex Radial Head Fractures: A Matched Pair Retrospective Study

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Purpose: Radial head replacement is indicated for complex radial head fractures that are not treatable with open reduction and internal fixation. Literature suggests an osteosynthesis is preferred if feasible. Implantation of a bipolar radial head prosthesis after radial head excision ensures stability of the elbow and forearm, thereby promoting ligament healing and restoring elbow and arm function. The purpose of the current study was to evaluate if a treatment with radial head prosthesis shows inferior results to an open reduction and internal fixation.

Methods: To compare the 2 groups according to their clinical outcomes, we chose a matched pair study design. We analyzed 52 patients with a radial head fracture. Pairs were matched to split them in 2 groups: 26 patients were treated with a Tornier, CRF II Bipolar Radial Head Prosthesis® (Group P) and the other 26 patients were treated with an osteosynthesis (Group O). The 2 groups were additionally divided into 2 subgroups each: 18 patients had an isolated radial head fracture, whereas 8 patients had a complex elbow trauma with additional ligament and/or bony injury. The mean follow-up was 42 months in Group P and 85 months in Group O. Clinical and ultrasonographic assessments were done. Final functional outcome was assessed by Disabilities of the Arm, Shoulder and Hand score (DASH), and range of motion (ROM) measurement, Strength test was done with a Jamar® Hydraulic Hand Dynamometer, and instability test with ultrasonographic dynamic measurement.

Results: The mean DASH was 27 (range, 0-73) within Group P and 24.2 (0-76) in Group O. For Group P the mean pain level (0-10) was 2.2 and 2.0 in Group O. Mean satisfaction level on a scale of 0-10 was 8.3 in Group P versus 8.2 in Group O. We discovered in Group P a persisting extension gap in 22 patients (mean 10.8°), average flexion was 118°, mean motion arcs were 108° in flexion-extension and 144° in pronation-supination. In comparison Group O showed a persisting extension gap in 21 patients (mean 16°), average flexion was 124°, mean motion arcs were 109° in flexion-extension and 155° in pronation-supination. For Group P mean forearm strength in midflexion was 64%, compared to the contralateral unharmed side. In Group O mean forearm strength in midflexion was 50%. In Group P first degree instability in varus/valgus stress showed in 10 patients. For Group O, 2 patients showed a first degree instability in varus/valgus stress.

Conclusion: Patients after implantation of a bipolar radial head prosthesis showed good results, especially the patients with an isolated radial head fracture. There were no significant differences evident within all examined parameters compared to the osteosynthesis group. The patients with associated injuries of bones and/or ligaments showed a worse outcome in both groups. This study shows that a prosthetic replacement of the radial head is a noninferior procedure to treat patients with a complex fracture of the radial head in comparison to an osteosynthesis.

See pages 401 - 442 for financial disclosure information.

Long-Term Results and Quality of Life After Thoracoscopic Anterior Stabilization for Thoracolumbar Fractures in Patients Without Spinal Cord Injury

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Purpose: In patients with severe traumatic thoracolumbar fractures, an insufficient load-bearing capacity might require anterior stabilization in addition to posterior fixation. Traditional autologous bone grafts come with specific disadvantages such as increased operating time, donor site morbidity, nonunion, and fracture of the strut graft. A distractible titanium cage prevents these disadvantages and combined with anterolateral plating provides stability, maintains kyphosis correction, and prevents posterior implant failure. Minimally invasive thoracoscopy reduces approach related morbidity but studies on thoracoscopic anterior stabilization are scarce and often report radiological and functional outcomes. Health-related quality of life (QOL), however, is an important outcome that has not yet been reported for this type of surgery.

Methods: This was a retrospective cohort study of patients treated between 2004-2012 in a university Level I trauma center. Patient and treatment characteristics were collected from the hospital information system. All available radiographic material was assessed for fracture characteristics and kyphosis at consecutive times. Patients were asked to fill in the Short Form-36 (SF-36) and EQ-5D QOL questionnaires at follow-up.

Results: Of 105 patients who were treated with a distractable cage, the procedure was performed thoracoscopically in 86 cases, including 16 patients with spinal cord injury. Of 70 eligible patient,s 46 were available for follow-up and filled in the questionnaires. QOL was lower on most domains compared to the general population. Compared to patients who underwent only posterior fixation for less severe fractures, QOL did not differ significantly. The complication rate was low (10%) with 1 reoperation. The mean loss of correction was 6.8° and bony fusion on CT scan was present in 98% of patients at follow-up. The maintenance of kyphosis correction was significantly better for 2-segment anterolateral plating compared to 1 segment.

Conclusion: Thoracoscopic anterior stabilization with a distractable cage leads to a high percentage of bony fusion in highly unstable thoracolumbar fractures with limited loss of reduction and no hardware failure. Health-related QOL of these patients does not return to normal population values but is comparable to that of patients with less severe fractures treated with only posterior instrumentation. The procedure is technically safe with no re-interventions needed due to cage dislocation or implant failure and has a low complication rate.

Δ Osseointegrated Implants for Transfemoral Amputees: Radiographic Evaluation of Bone Remodeling

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Purpose: Osseointegration is a novel method to overcome persistent socket prosthetic issues in amputees by anchoring a transcutaneous implant directly onto the skeletal residuum. Although similar technologies have been widely applied in the area of hip and knee arthroplasty, little evidence exists in the literature reporting the bone remodeling effects of osseointegrated implants. Stress shielding results in the reduction of bone density due to the implant removing the stress that is usually exerted on the bone, which greatly reduces implant stability. This study investigates the bone remodeling effect and quantifies it in 2 of the most common osseointegration implants.

Methods: This is a prospective study of 50 patients with transfemoral amputations, consisting of 35 males and 15 females, aged 20-73 years (mean 48.2) at surgery, with minimum 2-year follow-up. Two implants, the Integral Leg Prosthesis (ILP) and Osseointegrated Prosthetic Limb (OPL), with differences in tapering, coating, and bone ingrowth regions, were examined. Radiographs were taken at 6 months, 1 year, 2 years, and 5 years post-surgery. The surrounding bone was defined using inverse Gruen zones and graded into 5 levels of bone growth or resorption.

Results: Results obtained at 1 and 2-year follow-ups were compared to the 6-month follow-up values as a baseline. Significant bone growth near the proximal zones of the implant was observed on patients with the ILP implant. This was accompanied by significant resorption towards the distal end indicating the occurrence of stress shielding. The OLP implant demonstrated much more uniform bone density throughout the length of the implant.

Conclusion: Overall, the patterns of bone remodeling after osseointegration showed similarities to those seen on hip stems with a press-fit design. Of the 2 osseointegration implants examined in this study, the OLP implant exhibited less stress shielding effects and is expected to provide better long-term stability.

Δ OTA Grant

See pages 401 - 442 for financial disclosure information.

Inappropriate Weight Bearing After Surgical Treatment of the Lower Extremity Does Not Influence the Number and Severity of Complications

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Purpose: To support the healing patients, are often suggested to perform partial weight bearing after an operation of the lower extremity. Previous examinations has shown that people are often not able to follow these instructions. In this study 101 patients who underwent an operation of the lower extremity were observed to see if an incorrect loading influences the number of complications.

Methods: Between July 2015 and July 2017, 101 patients with injuries of the lower extremity were equipped with electronic shoe insoles, which are able to make a measurement of the loading and many other factors. The period of the measurement took 24 to 102 hours. The median duration of follow up was 490 days. Noticed were all complications that made a hospital stay necessary. In 49 cases the data were sufficient to make a statistical analysis, which was performed by using the chi square and Fisher exact test with significance set at $P < 0.05$.

Results: In 49 study participants we observed 7 complications in 7 patients. We have seen 4 wound complications, 1 implant failure, a chronic instability after a fracture of the tibia, and 1 implant loosening of a hip prosthesis. This patient was allowed to do full weight bearing and the average loading was 22.8 kg. The average weight bearing of the participant who incurred the implant failure of a dynamic hip screw was 15.4 kg, so he followed the surgeon's recommendation. In total 26 of the 49 patients were not able to follow the postoperative instructions. 5 of these patients occurred a complication, whereas 2 of the other 23 study participants were affected. There is no statistically significant correlation between high weight bearing and the occurrence of complications ($P = 0.29$).

Conclusion: The conclusion of this study is that on the one hand, most of the patients are not able to follow the partial weight-bearing instruction of the surgeon. On the other hand, it shows that an excessive loading does not seem to influence the number and severity of postoperative complications, especially with regard to implant failures. So we should evaluate stopping partial weight-bearing instructions.

The Results of Membrane-Induced Osteogenesis in Posttraumatic Bone Defects

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Purpose: It is absolutely challenging to treat posttraumatic bone defects surgically. Some of them are accompanied by soft-tissue defects and/or infection. Masquelet has reported that membrane-induced 2-step operation can accelerate osteogenesis in the zone with bone defects. First, remove the dead tissue completely, and then, reconstruct the soft tissue and fill the cement spacer in the zone with bone defect. Second, when the membrane equipped with osteogenesis is formed around the cement spacer, remove the spacer and perform a bone graft to treat the bone defects. We are performing membrane-induced osteogenesis for patients suffering from posttraumatic bone defects. Here, we are going to analyze the results of their treatment and also the effects of the operation.

Methods: From January 2014 until June 2016, among the patients having bone defects either posttraumatically or for a resection done in the process of getting treatment for posttraumatic osteomyelitis, we selected 54 subjects who had received treatment with membrane-induced osteogenesis and had been observed for over 1 year. Here, retrograde analysis was conducted. We cultured the tissue before removing the dead tissue from the zone with bone defects or debriding the tissue infected for osteomyelitis, and then, we cultured the tissue again after the debridement in order to evaluate the appropriateness of the treatment. We filled the antibiotic-loaded cement spacer in the zone with bone defects to form an induced membrane and repeated the debridement until the tissue culture was found to be negative. After treating the infection clinically, we operated the bone graft. We evaluated the length of bone defects and the presence of union radiologically. Analyzing the results of the tissue culture, we evaluated the recurrence of infection or initial bacteria.

Results: The mean age of the 54 patients was 46 years; 47 were males, and 7 were females. The average length of their bone defects was 81.77 mm. All patients, except for 8 cases in which infection recurred, got union. Infection recurred even though we operated the bone graft when the culture was found to be negative. Particularly, in 2 out of the 8 cases, before the bone graft, bacteria were never cultured in the tissue culture. Only in 1 out of the 8 cases, the bacteria identical to the initial ones recurred. In 1 case, the donor site for the bone graft showed infection. 5 out of the 8 recurrence cases have gained union, and 2 cases are waiting for union after the second operation; only 1 case has received amputation.

Conclusion: In patients with severe bone defects, induced-membrane osteogenesis can be an excellent treatment. It is also useful for treating bone defects accompanied with infection.

See pages 401 - 442 for financial disclosure information.

The Treatment of Complex Pediatric and Adolescent Tibial Fractures with The Ilizarov Method

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Purpose: We analyzed the functional and psychological outcomes in children and adolescents with complex tibial fractures treated with the Ilizarov method at our major trauma center.

Methods: Patients aged 17 years and younger treated with a circular frame for an acute tibial fracture between 2013 and 2016 were identified from our prospective database. Information from this database was supplemented by retrospective review of clinical notes and radiographs as well as routinely collected functional and psychological assessments. The patient-reported outcome measures administered 6 months post frame removal were the Pediatric Quality of Life Inventory (PedsQL) and a global health Visual Analog Scale (VAS) to assess how they rated their overall health on a scale of 0-100 (0 = worst possible health, 100 = best possible health).

Results: 74 patients (59 male, 15 female) aged between 4 and 17 years with 75 tibial fractures were identified. The average weight was 51 kg (range, 16-105). 26 patients had open fractures (6 with segmental bone loss) and 18 had associated physeal injuries. The remainder were closed fractures with unstable fracture patterns or significant soft-tissue compromise. 11 patients were included after failing alternative treatment. There was a 100% union rate with a median hospital stay of 4 days (interquartile range [IQR] 2-7) after frame application and a median frame time of 108 days (IQR 93-137). Malunions (>5° in any plane) were not observed and no serious complications occurred. Health-related quality of life measures (Peds QL), where available (78%), indicate return to high levels of function 6 months post frame removal (median PedsQL 88.04, IQR 70.32-100). The median global health VAS was 95 (IQR 80-99).

Conclusion: This largest series to date demonstrates the safety and effectiveness of the Ilizarov method in treating complex pediatric tibial shaft fractures, with 100% union and a low serious complication rate. Furthermore, patient-reported outcomes indicate high physical and psychosocial functioning following treatment.

Functional Outcome of Intra-Articular Tibial Plateau Fractures: The Impact of Posterior Column Fractures

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Purpose: Addressing posterior tibial plateau fractures is increasingly recognized as an important prognostic factor. The goal of this study was to assess the incidence of posterior column fractures and its impact on functional outcome and general health status. We aimed to identify all clinical variables that influence the outcome and provide insights in the treatment strategies.

Methods: A retrospective cohort study was conducted, including 218 intra-articular tibial plateau fractures that were treated both operatively and nonoperatively. All fractures were reclassified and applied treatment was assessed according to the updated 3-column concept. Relevant demographic and clinical variables were studied. The patient-reported outcome was assessed using the Knee injury and Osteoarthritis Outcome Score (KOOS).

Results: Median follow-up was 45.5 (interquartile range, 24.9-66.2) months. Significant outcome differences between operatively and nonoperatively treated patients were found for all KOOS subscales. The incidence of posterior column fractures was 61.9%. Posterior column fractures, sagittal malalignment, and an increased complication rate were associated with poor outcome. Patients treated according to the updated 3-column concept showed significantly better outcome scores compared to those patients who were not. We could not demonstrate the advantage of posterior column fracture fixation, due to the limited patient size (n = 14, 10.4%) and response (n = 9, 8.8%).

Conclusion: Our data indicate that implementation of the updated 3-column classification concept may improve the surgical outcome of tibial plateau fractures. Failure to recognize posterior column fractures may lead to inappropriate utilization of treatment techniques. The current concept allows us to further substantiate the importance of reduction and fixation of posterior column fractures with restoration of the sagittal alignment.

See pages 401 - 442 for financial disclosure information.

Clinical Outcomes of Combined Fixation Strategy Using a Mini Plate in Complex Patellar Fracture

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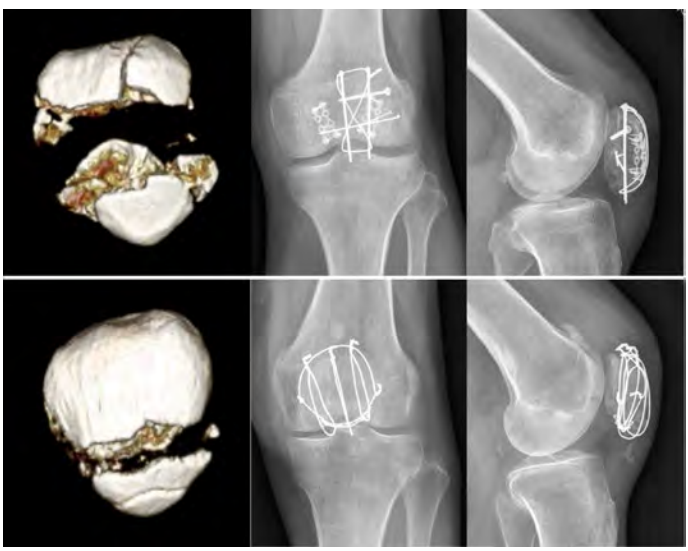
Purpose: The purposes of the study were (1) to introduce various applications of mini-plate augmented fixation and (2) to evaluate its clinical outcomes for complex patellar fracture.

Methods: Two orthopaedic trauma surgeons used single mini-plate augmented fixation technique managing complex patellar fracture from January 2014 to January 2016. Comminuted articular fracture was managed by tension band wiring augmented with anterior cortical plating. Comminuted inferior pole fracture was managed by separate vertical wiring augmented with rim plating. The patients were followed at regular intervals for a minimum of 12 months. The primary end point was radiologic union. A secondary end point was complications-related operation. Functional outcomes including range of motion were also evaluated.

Results: 33 patients were followed for an average of 14 months (range, 12-27). Average patient age was 56.6 years, and there were 18 male and 15 female. 25 patients were OTA 34 C fractures (C 3.2: 13, C 3.1: 9, C 2.2: 2, C 2.1: 1). 8 patients were OTA 34 A1 fractures (comminuted: 6). Tension band wiring with augmented anterior cortical plating was performed in 25 patients. Separate vertical wiring with rim plating was performed in 8 patients. The primary union rate was 94% (31 of 33 patients). Mean time to union was 3.2 months. Two patients required additional surgery resulting from acute postoperative infection and irritation of loosened screws.

Conclusion: Mini-plate augmented tension band wiring or separate vertical wiring could be a versatile and useful technique for complex patellar fracture fixation.



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Δ Improved Reduction of the Tibiofibular Syndesmosis with Tightrope Compared to Screw Fixation: Results of a Randomized Controlled Study

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Purpose: Flexible fixation of the tibiofibular syndesmosis is designed to allow increased ankle motion and better outcomes compared to screw fixation, and may improve the rate of anatomic reduction. This randomized, multicenter study compared the rate of malreduction following treatment of high fibular fractures associated with syndesmosis injury treated with open reduction and internal fixation with either screw or Tightrope fixation.

Methods: 103 patients from 11 sites were randomized and received fixation of their AO 44-C injury between June 2015 and June 2016. All patients demonstrated syndesmosis instability following malleolar fixation. Open reduction of the syndesmosis was performed in all cases. Fixation was randomized to either Tightrope (1 knotless Tightrope, Group T) or screw (two 3.5-mm cortical screws, Group S). Surgical techniques and rehabilitation were standardized. All surgeons were trained or experienced in the use of the Tightrope device. Follow-up was performed at 6 weeks, 3, 6 and 12 months. The primary outcome was the rate of malreduction based upon analysis of bilateral CT scans performed 3 months post injury. Secondary outcomes included adverse events and validated functional outcomes including the EQ-5D, Olerud-Molander Ankle Score (OM) and the Foot and Ankle Disability Index (FADI). Based on radiographic analysis, the study was powered for radiographic results only.

Results: The rate of malreduction using screw fixation was 39% compared with 15% using Tightrope (P=0.028). Analysis of CT results was performed using a 2-mm translation or 10°rotation threshold for malreduction and included fibular translation, syndesmosis distance, medial compression and rotation. Group T had greater syndesmosis diastasis compared to control limb (4.1 ± 1.3 vs 3.3 ± 1.4 mm, P=0.005) and less fibular medialization compared to Group S (1.04 ± 1.8 vs 0.3± 1.8 mm, P=0.05). Functional outcome measures demonstrated significant improvements over time, but no differences between the groups (p>0.3). FADI scores at each time interval were: 42 (T) vs 46 (S) (6 weeks), 75 vs 74 (3 months), 88 vs 86 (6 months) and 92 vs 89 (12 months). Unplanned reoperations were higher in the screw group compared to Tightrope (19% vs 2%, P=0.009) largely due to the rate of hardware removal.

Conclusion: Treatment of tibiofibular syndesmosis injury with the Tightrope device achieves lower rates of malreduction and hardware removal compared to screw fixation.

Δ OTA Grant

Fixation of Distal Tibia Fractures (UK FixDT): A Randomized Controlled Trial of Locking Plate Fixation Versus Intramedullary Nail Fixation in the Treatment of Adult Patients with a Displaced Fracture of the Distal Tibia

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Purpose: The treatment of displaced, extra-articular fractures of the distal tibia remains controversial. These injuries are difficult to manage due to limited soft-tissue cover, poor vascularity of the area, and proximity to the ankle joint. Most fractures are displaced and require surgical fixation to achieve the best outcome. The 2 most common forms of fixation are intramedullary nail fixation and locking plate fixation. Our objective was to assess ratings of disability in patients who have sustained a distal tibia fracture treated with either an intramedullary nail fixation or locking plate fixation.

Methods: Adult patients with an acute fracture of the distal tibia were eligible for this multicenter randomized clinical trial. Patients were excluded if there was a contraindication to intramedullary nailing, the fracture was open, the fracture extended into the ankle joint (iecintra-articular fracture), there was a contraindication to anesthesia, or there was evidence that the patient would be unable to adhere to trial procedures or complete questionnaires. Interventions were intramedullary nail fixation, which involves the insertion of a metal rod into the hollow center of the tibia, versus locking fixation, which involves attaching a plate on the surface of the tibia with fixed-angle locking screws. All surgery was performed according to the preferred technique of the operating surgeon. The Disability Rating Index (DRI) score was the primary outcome. Secondary outcomes were the Olerud and Molander ankle score, the EQ-5D 3L health-related quality of life questionnaire, complications, and radiographs at 3, 6, and 12 months postoperatively. Resource use was collected to inform the health economics evaluation.

Results: 320 patients were randomized into the trial. There was a statistically significant and clinically important difference in the DRI at 3 months in favor of nail fixation (8.8 (4.3, 13.2); $P < 0.001$). This difference reduced at the primary end point of 6 months (4.0 [-1.0, 9.0], $P = 0.114$) and again at 12 months (2.3 [-3.0, 7.7], $P = 0.394$). Secondary outcomes showed the same pattern. There was no difference in the number of complications but further surgery was more common in the locking plate group. The economics evaluation showed that nail fixation was cheaper than locking plate fixation over the 12 months of the trial.

Conclusion: This study shows that intramedullary nail fixation provides faster recovery for patients with a fracture of the distal tibia and costs less than locking plate fixation. If operative fixation is required, patients with this injury should be offered an intramedullary nail as the treatment of choice.

See pages 401 - 442 for financial disclosure information.

UK Wound Management of Open Lower Limb Fractures (UK WOLLF): A Randomized Controlled Trial of Standard Wound Management Versus Negative Pressure Wound Therapy in the Treatment of Adult Patients with an Open Wound Fracture of the Lower Limb

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Purpose: Open fractures of the lower limb occur when a broken bone penetrates the skin and is exposed to the outside environment; these are life-changing injuries. The risk of deep infection may be as high as 27%. The type of dressing applied after surgical debridement could potentially reduce the risk of infection in the open fracture wound. We compared standard wound dressings with a new treatment, negative pressure wound therapy (NPWT), for adults with open lower limb fractures.

Methods: Patients were recruited from 22 trauma centers in the UK. 460 consented patients presenting with a severe, open lower limb fracture were randomly assigned to receive either a standard wound dressing or NPWT after the first surgical debridement of the open fracture. The primary outcome was the Disability Rating Index (DRI) at 12 months after surgery. Secondary outcomes were health-related quality of life, deep surgical site infection, other complications, and resource use.

Results: There was no evidence of a difference in the patients' DRI at 12 months. The mean DRI in the NPWT was 45.5 (28.0) versus 42.4 (24.2) in the standard dressing group, giving a difference of 3.9 (95% confidence interval, -8.9 to 1.2) in favor of standard dressings (P = 0.132). There was no difference in health-related quality of life, the number of surgical site infections, or other complications at any point in the 12 months after surgery. NPWT did not reduce the cost of treatment.

Conclusion: Contrary to the existing literature and current clinical guidelines, NPWT dressings do not provide a clinical or cost benefit for patients with an open fracture of the lower limb.

Δ Operative Versus Nonoperative Treatment of Acute Displaced Distal Clavicle Fractures: A Multicenter Randomized Controlled Trial

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Purpose: While numerous randomized studies have demonstrated the benefits of surgical fixation in midshaft clavicle fractures, the treatment of distal clavicle fractures remain controversial. To date, there have been no RCTs comparing operative and nonoperative treatment of displaced, distal clavicle fractures.

Methods: This is a multicenter RCT, and patients were randomized to (1) open reduction internal fixation (ORIF) with a plate or (2) nonoperative treatment with a sling. Inclusion criteria were: age 16-60 years, with a completely displaced, closed, fracture of the distal third of the clavicle.

Results: In total 57 patients were randomized: 27 to the operative group and 30 to the nonoperative group. Mean age was 42 years, and 86% were male. There were no differences between the 2 groups regarding baseline characteristics. Overall, patients demonstrated improvement of DASH and Constant scores at 1 year post injury (mean DASH = 11, mean Constant = 87), but there were no differences between the 2 groups at any time point. There were no differences between the 2 groups with regard to rate of return to work, or return to activity at any time point. Patients in the nonoperative group had a higher rate of nonunion (37% vs 4%, P = 0.002), and malunion (40% vs 4%, P = 0.001), and a longer time to union (42% at 6 months, vs 95% in the operative group, P = 0.0001). The rate of secondary surgical procedures were similar between the 2 groups: 7 patients in the nonoperative group required 10 operations (33%, for surgical fixation of a nonunion and subsequent hardware removal) compared to 13 patients in the surgical group (48%, all for hardware removal, P = 0.26).

Conclusion: This is the first randomized controlled trial of distal clavicle fractures. This study reveals that nonoperative treatment of distal clavicle fractures results in high rates of nonunion (37%) and malunion (40%). Plate fixation is safe and effective in significantly lowering the rate of nonunion and malunion; however, patient-related outcomes (DASH and Constant scores) show similar outcome irrespective of treatment. It is possible that the presence of distal clavicle nonunion or malunion causes minimal functional deficits in most individuals. It is also possible that the current outcome measures available are not sensitive enough to capture functional deficits in patients with these injuries, and more investigation is required in this area.

Δ OTA Grant

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Does Motion at 8 Weeks Predict Nonunion in Nonoperatively Managed Humeral Shaft Fractures? A Prospective Multicenter Evaluation

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Purpose: An important factor to patients in deciding on operative versus nonoperative management for humeral shaft fractures is how long it will take to know if they will unite if treated nonoperatively. We prospectively evaluated gross motion at the fracture site at 8 weeks as a potential indicator of future nonunion in humeral shaft fractures with the hypothesis that a lack of gross motion of the fracture at 8 weeks would predict union in patients treated nonoperatively.

Methods: As part of a comparative study, we screened all patients with an acute humeral shaft fractures at 13 centers. We are reporting on those treated nonoperatively with a functional brace. Follow-up was at 4, 8, 12, 26, and 52 weeks. At each visit the fracture was examined for gross motion, visual analog scale (VAS) pain, and callus presence or not on all 4 cortices. We evaluated those with versus those without gross motion at 8 weeks.

Results: We prospectively enrolled 101 (52% M) patients aged 18-71 years (mean 41) with humeral shaft fractures (OTA 12A-C). 4 patients chose operative treatment prior to 8-week follow-up, 7 did not have a documented examination of motion, and 14 were lost to follow-up at <8 weeks, leaving 80 patients. Neither the body mass index (29 vs 31) nor the ISS (6.8 vs 6.9) were different for those with and without motion. 62 (77%) had no motion and 18 (23%) had gross motion at the fracture site at 8 weeks. 58 patients who had no gross motion went on to union (the other 4 were lost to follow-up). Of the 18 patients who had gross motion at 8 weeks, 2 were lost to follow-up, 7 (44%) healed, and 9 (56%) went on to surgery. The VAS score at 8 weeks for those who had gross motion and united was not different than those who did not (P = 0.7). Callus was present on 3 of 4 cortices in 6 of the 7 who went on to union and only 3 of the 9 who went on to surgery (P = 0.06). Excluding those lost after 8 weeks, the positive predictive value (PPV) and negative predictive value (NPV) for a lack of gross motion resulting in union without surgery was 100% and 56% (9 of 16 went on to surgery).

Conclusion: These data strongly suggest that a lack of motion at 8 weeks predicts union and that patients with gross motion with a lack of callus formation may benefit from surgical intervention.

Multicenter Retrospective Analysis of Humeral Shaft Fractures: Are Sarmiento's Results Widely Reproducible?

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Purpose: The purpose of this multicenter study is to evaluate in a large cohort the rate of conversion from closed treatment of humeral shaft fractures with a fracture brace to surgical intervention, and the reasons for change in patient management.

Methods: Patients with a closed humeral shaft fracture managed nonoperatively with a functional brace from 2005-2015 were reviewed retrospectively from 8 trauma centers. Patients <18 years old, pathologic and periprosthetic fractures, nondiaphyseal fractures, and patients lost to follow-up before union or conversion to surgery were excluded. Demographics, mechanism of injury, fracture characteristics, comorbidities, neurovascular injuries, and fracture union were recorded. In the event of conversion to surgery, time from injury to surgery and reason were entered. Univariate and regression analysis were performed to find variables associated with a higher rate of conversion to surgical treatment.

Results: 1269 patients were included in the study. Mean age was 47 years (range, 18-92) with 49% being male. 11% presented with symptoms of radial nerve palsy before application of the fracture brace. Successful union was achieved at an average of 15 weeks. A total of 344 fractures (27%) were converted to surgical intervention. Of those, 60% developed a nonunion, 24% had malalignment beyond acceptable parameters, 12% were noncompliant to functional brace, and 4% had persistent signs of radial nerve palsy requiring exploration. 10 patients (3.9%) converted to surgery required a subsequent intervention. All patients with radial nerve palsy fully recovered except one. Univariate comparisons showed that females and Caucasians were significantly ($p < 0.05$) more likely to be converted to surgery. The multivariate logistic regression identified females as being 1.6 times more likely and smokers to be 1.8 times more likely to be converted to surgery ($P < 0.05$). No specific fracture pattern was linked to a higher rate of conversion.

Conclusion: This large multicenter study identified a 27% surgical conversion rate, with nonunion as the most common reason for surgical intervention. These results are markedly different than previously reported. One out of four humeral shaft fractures treated conservatively at these trauma centers are converted to surgical intervention. These modern results may be helpful when counseling patients on choosing between functional bracing and surgical intervention for humeral shaft fractures.

See pages 401 - 442 for financial disclosure information.

The FaB (Fractures and Bisphosphonates) Trial: A Multicenter, Double-Blind, Randomized Controlled Trial on the Effect of Alendronic Acid on Healing and Clinical Outcomes of Wrist Fractures

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Purpose: There is currently no consensus on whether bisphosphonate therapy should be withheld following a low-energy fracture of the distal radius due to the potential concerns about an adverse effect on bone healing. The primary aim of this multicenter, double-blind, randomized placebo controlled trial was to determine if there is any difference between alendronic acid versus placebo on the union rate at 4 weeks post treatment in patients ≥50 years who have sustained a fracture of the distal radius. The null hypothesis was that there is no difference in union rates between groups at 4 weeks post treatment.

Methods: We performed a registered multicenter (n = 15), double-blind, randomized placebo controlled trial in 421 patients ≥50 years of age with an acute radiographically confirmed nondisplaced or displaced fracture of the distal radius. Patients were randomized to either alendronic acid 70 mg once weekly (n = 215) or placebo (n = 206), and were reviewed at 2 weeks, 4 weeks, 6 weeks, 2 months, and 6 months following injury. The primary outcome measure was the percentage of fractures united at 4 weeks.

Results: The baseline demographic and fracture characteristics of the 2 groups were comparable. The 4-week follow-up rate was 92% (n = 389) and the 6-month follow-up rate was 90% (n = 380). Study treatment compliance was 85.2% (n = 359). There was no statistically significant difference (-4.1%; 95% confidence interval [CI], -12.8 to 4.7; P = 0.53) in fracture union rates between the alendronic acid group (23.8%; 95% CI, 17.9 to 29.6) or the placebo group (27.8%; 95% CI, 21.4 to 34.2) at 4 weeks. No difference was also seen in union rates at 6 weeks (44.6% vs 44.2%; P = 0.88) or 2 months (61.7% vs 56.3%; P = 0.19). There was also no difference at any time point between the 2 groups in terms of the Disabilities of the Arm, Shoulder and Hand (DASH), pain, grip strength, malunion rates, or the prevalence of complex regional pain syndrome (P >0.05 for all).

Conclusion: This large multicenter trial demonstrated that the early administration of alendronic acid did not alter fracture union rates or clinical outcome when compared to placebo in patients ≥50 years who sustain a fracture of the distal radius. We would recommend that there is no indication for clinicians to withhold bisphosphonate therapy in patients who sustain a fracture of the distal radius. Further work is required to determine if this practice can be adapted for other osteoporotic fractures.

Costs and Complications of Single-Stage Fixation Versus 2-Stage Treatment of Select Bicondylar Tibial Plateau Fractures

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Purpose: Many surgeons advocate a 2-stage approach with initial external fixation and delayed fixation for bicondylar tibial plateau (BTP) fractures. Recent evidence has shown that selected BTP fractures can be treated with early definitive fixation with a low rate of complications. This investigation examines the difference in cost and complications among BTP fractures treated with single-stage definitive fixation versus 2-stage treatment.

Methods: We performed a retrospective review of all BTP fractures (OTA 41-C) treated at a Level I trauma center from 2013-2015. Inclusion criteria were age ≥17 years and follow-up to healed fracture (minimum 6 months). Charts and radiographs were reviewed. Functional outcomes were assessed with the PROMIS (Patient-Reported Outcomes Measurement Information System) score. Direct implant-related costs and hospital charges were obtained via hospital data. Outcomes and costs were compared between patients with 1-stage and 2-stage fixation.

Results: There were 28 patients in the 1-stage group and 24 patients in the 2-stage group after exclusions. Mean follow-up was 21.8 months. Mean implant cost in the 2-stage group was $10,768 greater than the 1-stage group. Median inpatient charges in the 2-stage group exceeded the 1-stage group by over $68,000. There was no difference between groups with respect to complications or functional outcomes.

Conclusion: This study demonstrated that single-stage definitive treatment of BTP fractures dramatically decreases costs without an increase in complications in selected patients.

		One-Stage Fixation	Two-Stage Fixation	P-value
	Number of Patients	28	24	
Demographics and Comorbidities	Age (mean)	48	51	0.48
	Sex (M:F)	14:14	17:7	0.16
	BMI (mean)	30	31	0.43
	Smoker (%)	36	42	0.78
	Diabetes (%)	18	17	1.00
	Osteoporosis (%)	3	4	0.91
Injury Data	OTA 41-C3 : OTA 41-C1/2	24:4	24:0	0.12
	Number of days to definitive fixation (mean)	1.25	7.8	**<0.01**
	Number of days to definitive fixation (range)	0-3	3-15	
	Open Fracture (%)	14	4	0.36
Clinical and Radiographic Outcomes	Unplanned Reoperation (%)	7	29	0.06
	Nonunion (%)	4	13	0.32
	Deep Infection (%)	7	17	0.40
	Change in Coronol or Sagittal Alignment >5 deg (%)	11	17	0.69
	PROMIS Physical Function	40	40	0.82
	PROMIS Pain Interference	61	56	0.10
Cost	Implant Cost (mean)	$3,475	$14,243	**<0.01**
	Inpatient Hospital Charges (mean)	$97,608	$182,942	**<0.01**
	Inpatient Hospital Charges (median)	$90,085	$158,658	**<0.01**
	Inpatient Hospital Charges for Isolated BTP (mean)	$74,438	$153,519	**<0.01**
	Inpatient Hospital Charges for Isolated BTP (median)	$72,285	$134,009	**<0.01**

Table 1. Staged treatment of bicondylar tibial plateau fractures resulted in significantly higher hospital charges and implant costs in comparison to patients treated with early definitive fixation. There were no differences observed between the groups with respect to demographics, comorbidities, clinical, and radiographic outcomes.

See pages 401 - 442 for financial disclosure information.

Locking Plate Fixation of Bicondylar Tibial Plateau Fractures Raises Treatment Costs Without Clinical Benefit

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Purpose: Lateral locking plates are popular for the treatment of bicondylar tibial plateau (BTP) fractures. Studies have shown variable results when comparing lateral locked plating to conventional nonlocked dual plating for BTP. There is limited data on the value (outcome:cost ratio) of implant options. We hypothesized that lateral locked plating would increase cost without affecting clinical outcomes in comparison to nonlocked dual plating of BTP.

Method: We reviewed all BTP fractures (OTA 41-C) age >17 treated by 6 fellowship-trained surgeons from 2013-2015 with followup >12 months. Charts were reviewed for demographic, clinical, and radiographic data. Functional outcomes were assessed via PROMIS scores (Physical Function [PF] and Pain Interference [PI] domains). Implant costs were calculated using intraoperative inventory software and accuracy was confirmed with radiograph review. Outcomes and costs were compared between patients with nonlocking (NL) versus locking (L) implants.

Results: 59 patients were included (30 NL, 29 L). Mean follow-up was 24.3 months (range, 12-41). The groups had similar demographic profiles and fracture characteristics (95% OTA 41-C3) (Table 1). We observed a 70% higher cost of implants in the L group. (Table 1) No differences in clinical or radiographic outcomes were found (Table 1). Analysis of the L group showed no difference in outcome among patients that had adjunctive medial fixation.

Conclusion: This investigation found no clinical benefit to the use of locking implants in BTP fractures, despite a significantly larger cost incurred.

		Locking group	Nonlocking group	P-value
	Number	29	30	
Demographics	Age (mean)	51	48	0.39
	Sex (M:F)	17:12	20;10	0.60
	BMI (mean)	30	30	0.58
	Smoker (%)	52	33	0.19
	Diabetes (%)	21	17	0.75
	Osteoporosis (%)	7	6	0.61
Fracture Characteristics	OTA Class 41-C1/2 (%)	0	10	0.24
	OTA Class 41-C3 (%)	100	90	
	Open Fracture (%)	10	3	0.61
	Adjunct Medial Plate (%)	62	87	**0.04**
Clinical and Radiographic Outcomes	Reoperation (%)	38	20	0.16
	Nonunion (%)	10	7	0.67
	Deep Infection (%)	21	10	0.30
	Change in Alignment >5 deg (%)	7	10	1
	PROMIS Physical Function	39	42	0.20
	PROMIS Pain Interference	60	56	0.18
	Mean Cost (Std Dev)	**$ 5443 (2567)**	**$ 3194 (1470)**	**<0.01**

Table 1. Significantly higher costs were incurred in the locking implant group compared to the nonlocking group. There were no differences observed between the groups with respect to demographics, fracture characteristics, clinical, and radiographic outcomes.

Single Screw Fixation Compared with Double Screw Fixation for Treatment of Medial Malleolar Fractures: A Prospective Randomized Trial

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Purpose: With medial malleolar fractures, surgeons typically utilize 2 screws to ensure rotational control of the bone fragment. A prospective randomized trial was performed to determine whether single or double screw fixation of the medial malleolus resulted in better long-term health outcomes. The primary outcome was a comparison of physical functioning summary score on Short Form-36 (SF-36) questionnaires between patients in the 2 groups.

Methods: Giving each group 80% power to detect a difference of 5%, a sample size of 63 patients per group was utilized. Any patients who crossed over from the single screw (SS) to the double screw (DS) group, or vice versa, were analyzed according to the "intention to treat" principle. 140 patients were randomized to receive either 1 or 2 screws to repair their medial malleolar fracture followed by equivalent rehabilitation. 13 patients were excluded due to early loss to follow-up or withdrawal (n = 127; initial SS n = 61, initial DS n = 66). Clinical assessment occurred at the time of surgical consultation and 2 weeks, 6 weeks, 3 months, 6 months, 12 months, and 24 months postoperatively. Functional outcome results were also measured at the same time points using functional outcome questionnaire SF-36 and AHS.

Results: There were no differences between the groups as far as demographic data or complications. 14 patients crossed over from the DS group to the SS group based on intraoperative decisions by the surgeon (fragment too small for 2 screws ["intention to treat" still followed]) leaving SS (n = 75) and DS (n = 52). Between groups there was no significant difference in operating room (OR) time (SS mean OR time = 44.5 (± 21.9) minutes; DS mean OR time = 47.0 (± 18.3) minutes; P = 0.5). There were no significant differences between SS and DS groups on all 8 categories of SF-36 scores at the baseline, 3-month, or 24-month follow-up time points. Despite this number of patients, there was no indication of a difference when it came to hardware pain or need for removal.

Conclusion: The 2-year functional outcome scores prove that single screw medial malleolar fixation provides an equally safe and effective method of fracture care as compared to double screw fixation. Approximately 21% of patients (14 of 66) receiving DS fixation can be expected to crossover to receive SS fixation as a safer alternative (avoid fracturing small malleolus). A single screw used by surgeons in this study provided no failures in fixation, malunion, or rotation.

See pages 401 - 442 for financial disclosure information.

Weight Bearing or Non-Weight Bearing After Surgical Treatment of Ankle Fractures: The WOW! Study. A Multicenter Randomized Controlled Trial

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Purpose: The aim of this trial was to provide evidence for the optimal postoperative care regimen after surgical repair, solely for Lauge Hansen supination exorotation stage 2, 3, and 4 ankle fractures. The null hypothesis was that ankle-specific disability assessed with the Olerud Molander Ankle Score (OMAS) is less for unprotected weight bearing when compared to protected weight bearing and unprotected non-weight bearing.

Methods: A multicenter, randomized controlled trial was performed in 4 different level hospitals in the Netherlands. Patients, ranging from 18 to 65 years of age, with a supination exorotation type 2, 3, or 4 ankle fracture were included. All fractures had an articular incongruity of >2 mm on the radiograph. Before inclusion of a patient the following criteria had to be met in the following order: (1) the patient's informed consent had to be obtained, (2) the fracture was classified by at least 3 out of 6 trauma surgeons in the expert panel as a supination exorotation ankle fracture, and (3) the operating surgeon had to agree with the inclusion of the patient after testing the syndesmosis during the operation followed by a successful operative treatment. Patients were randomized using a computerized random number generator. The 3 postoperative care regimens were: (1) unprotected non-weight bearing, (2) protected weight bearing, or (3) unprotected weight bearing. The primary end point of the study was the OMAS, which was filled out at 6 weeks, 12 weeks, 6 months, and 1 year after randomization.

Results: A total of 115 consecutive patients with a mean age of 39 (±14) years were included. Randomization took care of an even distribution of baseline characteristics between the 3 groups. The OMAS showed significant better results in the unprotected weight-bearing group after 6 weeks. All other follow-up moments did not show significant different between the groups. There were no significant differences in the rate of complications between groups.

Conclusion: Unprotected weight bearing and mobilization as tolerated is a safe postoperative care regimen in adult patients without comorbidities with a supination exorotation type 2, 3, or 4 ankle fracture. Unprotected weight bearing and mobilization as tolerated shows a better functional outcome in the short term.

The AIM Trial Extended Follow–up: Three-year Outcomes from an Equivalence Randomized Clinical Trial Comparing Close Contact Casting with Internal Fixation Surgery for Unstable Malleolar Fractures in Patients Over 60 Years

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Purpose: The AIM Trial was previously reported at OTA 2015 and published in *JAMA* (2016). Close contact casting (CCC), a novel casting technique, was compared with open reduction and internal fixation (ORIF) surgery for the initial treatment of unstable malleolar fracture in older adults. There was equivalence between the treatment groups in terms of ankle function at the primary endpoint of 6 months. There were no differences in secondary outcomes of quality of life (mental and physical), ankle range, pain, mobility and patient satisfaction. However, there was a greater number of participants with radiological malunion in the casting group, leading to concerns about the potential for later deterioration in ankle function. The duration of follow-up was extended to investigate the important clinical uncertainty about whether equivalence would be maintained in the longer term.

Methods: The AIM Trial was a pragmatic, multi-center, equivalence, randomized controlled trial incorporating health economic evaluation. 620 participants aged 60 and over (mean: 71) were randomized to ORIF or CCC. Recruitment was from 24 hospitals. The primary outcome was the Olerud and Molander Ankle Score (OMAS). Secondary outcomes were: pain, health-related quality of life (EQ-5D-3L and SF-12), and additional operating room procedures. Longer term follow-up was via postal questionnaire at least 3 years post intervention. Consistent with the published protocol, the primary analysis was per protocol with an equivalence margin pre-set at +/- 6 OMAS points. Current Controlled Trials ISRCTN04180738.

Results: Follow-up assessments at median 3 years (range 2.9 to 9.5 years) post intervention were completed by 450/620 (73%) participants, 90/620 did not respond or did not agree to participate, 35/620 had died, and 45/620 had withdrawn. OMAS mean difference between CCC and ORIF was 1.2 [95%CI: -3.1, 5.5]. Analyses of secondary outcomes will be presented.

Conclusion: Equivalence in functional outcome between CCC and ORIF is maintained at 3 years. These longer term outcomes provide additional evidence to support surgeons and patients when offering or selecting CCC as an alternative to surgery in older adults with an unstable ankle fracture.

See pages 401 - 442 for financial disclosure information.

An Immediate Weight-Bearing Protocol for the Determination of Ankle Stability in Patients with Isolated Distal Fibular Fractures

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Purpose: Treatment of isolated distal fibular fractures relies on the ability to determine ankle stability radiographically. Current studies suggest the ankle should be stressed, by either a manual or gravity stress radiograph. We evaluated our protocol of allowing immediate weight bearing as tolerated (WBAT) in a functional walking boot in patients with isolated distal fibula fractures and no medial clear space (MCS) widening (44-B1) on nonstressed initial radiographs with subsequent weight-bearing radiographs at 1-week follow-up. We sought to determine if this protocol would allow us to differentiate stable (44-B1) from unstable (44-B2.1) fractures.

Methods: This study is a retrospective case series of patients with isolated distal fibular fractures managed by our authors between 2007 and 2012. Inclusion criteria include isolated distal fibula fractures with no widening of the ankle mortise (MCS 4 mm) were treated with operative fixation. Radiographs were repeated at approximately 6 weeks, or until radiographic union.

Results: Between 2007 and 2012, 185 isolated distal fibula fractures were treated at our institution. 74 patients presented with initial ankle mortise widening and operative treatment was recommended. A total of 87 patients with no initial MCS widening met the inclusion criteria, and were managed per the study protocol. Two of the 87 (2.3%) widened at 1-week follow-up with weight-bearing radiographs and underwent operative fixation. The remaining 85 patients were treated nonoperatively. None of these 85 patients had evidence of MCS widening on weight-bearing radiographs at time of radiographic healing.

Conclusion: These results suggest that our immediate weight-bearing protocol is an effective method for the determination of functional ankle stability in the setting of an isolated distal fibula fracture. Further investigation with a randomized study comparing our protocol to stress radiographs is warranted.

Rate of Syndesmotic Instability Following Anatomic Posterior Malleolar Fracture Open Reduction and Internal Fixation

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Purpose: This study sought to define the rate of distal tibiofibular syndesmotic instability following the anatomic reduction of the posterior malleolus when direct posterior stabilization of a trimalleolar ankle fracture (AO/OTA 44 B3 or C type fractures) was chosen. Conversely, we wanted to evaluate the rate of syndesmotic and posterior instability when a supine position and initially conservative management of the posterior elements was chosen.

Methods: We identified all adult posterior malleolar ankle fractures treated at our Level I trauma center from January 2012 to December 2015. Exclusion criteria included pilon fractures, trimalleolar fractures with Chaput fragments, and neurologic injury. Demographic information, fracture classification, initial operative position, medial clear space, and posterior malleolar fragment size were recorded for each fracture. We assessed the use and type of syndesmotic and posterior malleolar fixation used in these injuries.

Results: Data on 198 patients were analyzed. 151 patients (76.3%) were initially positioned supine, 41 of whom (27.2%) had syndesmotic instability requiring operative stabilization. Of the 110 supine patients who did not require syndesmotic stabilization, 32 (29.1%) required posterior malleolar stabilization for posterior instability. 47 patients (23.7%) were initially positioned prone. Following anatomic reduction and internal fixation of the posterior malleolus, syndesmotic stability was restored in 46 of 47 patients (97.9%). This 2.1% rate of instability is in stark contrast to the 13-fold higher syndesmotic instability rate seen in the supine group ($P < 0.001$).

Conclusion: Using traditional preoperative estimates of posterior stability may be inadequate. When patients were positioned supine based on small posterior malleolar fragment size, stabilization of the posterior fragment or syndesmotic fixation was required nearly 28% of the time. When initial posterior malleolar fixation was chosen, syndesmotic fixation was extremely rare. Findings suggest that it may be beneficial to anatomically reduce and stabilize the posterior malleolus at a higher rate to allow for adequate ankle stability, more reliable restoration of syndesmotic anatomy, and prevent surgical injury to the distal tibiofibular joint.

See pages 401 - 442 for financial disclosure information.

Evaluation of a Custom Energy-Storing Lower Limb Carbon Fiber Orthosis

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Purpose: The Intrepid Dynamic Exoskeletal Orthosis (IDEO) is a custom, energy-storing carbon fiber orthosis developed for lower limb salvage patients. Early studies conducted at one military treatment facility (MTF) where the IDEO was developed demonstrate benefits of the IDEO when used with a sports medicine approach to physical therapy (PT). This study was designed to see if we could replicate results at other MTFs, and examine if early gains in performance translate into longer-term improvements in patient-reported outcomes.

Methods: The study is a pre-post design where participants served as their own controls. Eligible were service members who were at least 1 year out from an injury at or below the knee with functional deficits. Participants were evaluated before receiving the IDEO (T0), immediately following completion of PT (T2), and 6 months (T3) following PT. Functional performance was assessed using several well-established tests. Self-reported function was measured using the Short Musculoskeletal Function Assessment (SMFA). The Orthotics and Prosthetics Users' Survey (OPUS) was administered at T2 and T3 to assess satisfaction with the IDEO.

Results: Of 87 participants with complete baseline data, 6 did not complete any PT and were excluded from analysis. The mean number of sessions attended by participants was 9.2; 83% attended 7 or more sessions. 88% of participants completed the T2 assessment and 74% completed the T3 SMFA. Compared to baseline, statistically significant improvement at T2 was observed in all but 1 performance test. SMFA scores were significantly lower at 6 months compared to baseline in Mobility (30.1 vs 37.6; 95% confidence interval [CI] of difference: -11.9, -2.9) and Daily Activity (25.1 vs 32.1; 95% CI: -11.3, -2.7). There was no impact on high baseline emotional subscores of the SMFA. Satisfaction with the IDEO was high at T2 (91% had OPUS scores >65) with some attenuation at T3 (68%).

Conclusion: This study adds to the evidence in support of the efficacy of the IDEO and PT in improving function, regardless of where it was fabricated and fitted. But despite improvement in both performance and self-reported functioning at 6 months, deficits persist compared to population norms. Results support the need for further refinement of the IDEO and continued efforts at addressing psychosocial consequences.

Limb Salvage and Amputation Outcomes Following Severe Distal Tibia and Hindfoot Injuries

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Purpose: The decision to salvage or amputate a severe distal tibia or hindfoot injury is still under debate. Evidence suggests that some salvage patients may do better with an early below-knee amputation. This cohort study collected functional outcome data on patients undergoing salvage versus early amputation (within 6 weeks) following these injuries. We hypothesized that there would be a subgroup of salvage patients who would have had better outcomes had they undergone amputation.

Methods: 32 US trauma centers enrolled patients (18-60 years of age) with severe injuries to the distal tibia, ankle, or hindfoot and followed them for 18 months. The primary outcome was patient-reported function as measured by the Short Musculoskeletal Function Assessment (SMFA). We compared outcomes for salvage patients to the outcomes these patients would have had, if they had undergone amputation. This causal analysis relies on the assumption that, after accounting for baseline patient characteristics and characteristics of the non-study injury, there are no additional factors that are associated with both an individual's outcome after amputation and the decision to amputate.

Results: The analysis is based on 87 patients undergoing amputation and 408 undergoing limb salvage (170 with open Type III pilon or Type IIIB/C ankle fractures; 85 with open Type III B/C talus or calcaneus fractures; 153 with other severe crush or blast injuries to the foot from high-injury mechanisms). The average age was 38.5 years; 64% were male. Observed SMFA outcomes were uniformly worse across all domains of the SMFA for salvage versus amputation patients (eg, 38.5 vs 29.8 on the mobility subscore). We estimate that for all domains except daily activities, outcomes for salvage patients are significantly worse than had they undergone amputation; differences over all patients were modest (eg, salvage patients have a mobility score that is 7.93 points (95% confidence interval: 3.14, 12.62) higher than their score had they undergone amputation. Results vary by principal injury with the difference being largest for open pilon/ankle fractures. The presence of other ipsilateral injuries contributed to a slightly larger but statistically significant difference in outcome.

Conclusion: This study suggests that for some types of severe foot and ankle injuries, patient-reported outcomes might be better under amputation versus limb salvage. Further analyses comparing objective measures of functional performance are needed.

See pages 401 - 442 for financial disclosure information.

Calcaneal Avulsion Fractures in 35 Consecutive Patients Treated Over 17 Years at a Level I Trauma Center: An Injury Pattern Fraught with Soft-Tissue and Bony Complications

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Purpose: Calcaneal avulsion fractures are rare injuries, presumably the result of the powerful contraction of the gastrocsoleus complex and resultant displacement of the bony insertion of the Achilles tendon. As these fractures often occur in diabetic and elderly hosts with compromised soft and bony tissues, thoughtful surgical decisions including timing and fixation methods seems imperative. Our goal was to evaluate outcomes of calcaneal avulsion fractures in a sizable consecutive cohort treated at our center.

Methods: We reviewed all calcaneal fractures treated at our institution from 2000 to 2017 and reviewed imaging and clinical data to identify all calcaneal avulsion fractures that presented over this 17-year period. We collected demographics, comorbidities, mechanism, presence of soft-tissue compromise, fixation construct, incidence of hardware failure or fracture displacement, and need for additional procedures. A univariate analysis was performed to determine which patient factors were associated with fracture displacement or hardware failure.

Results: We identified 35 patients with calcaneal avulsion fractures treated over the study period. 29 patients were treated operatively and 6 were treated closed. The overall complication rate was 60% (21 of 35). 15 patients (43%) had either an open fracture or soft-tissue compromise at the time of presentation. Of those patients treated operatively with 3-month follow-up (n = 27), 8 (29.6%) had catastrophic failure of their hardware and loss of fixation. When including those with fracture displacement without loss of fixation (n = 4), 44.4% of patients (12 of 27) had radiographic evidence of fracture displacement. 8 patients (29.6%) required a secondary operation. No patient factor was associated with an increased risk of failure. There was no difference in the incidence of failure in high versus low-energy fractures (45.4% vs 40.0%, P = 0.78). Use of a washer or addition of a soft-tissue procedure (Strayer, suture anchor, etc) did not have a significant effect on failure rate.

Conclusion: Calcaneal avulsion fractures treated at our center had a high overall complication risk of 60%. Soft-tissue compromise relating to the timing of presentation and surgery was 43%, combined with high fixation failure rate of 44% following operative treatment. This high-risk injury should be identified and treated early acknowledging that risks are high. Improvements in fixation over 2 screws alone should be strongly considered.

Syndesmotic Disruption in Tibial Plafond Fractures:
What Are The Risk Factors for Missing the Diagnosis?

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Purpose: Missed syndesmotic injury is associated with poor functional and radiographic outcomes. The purpose of this study was to identify the incidence of syndesmotic injury in tibial plafond fractures, describe fracture characteristics associated with syndesmotic injury, and report the incidence of posttraumatic osteoarthritis (PTOA).

Methods: Following IRB approval, we retrospectively reviewed all tibial plafond fractures treated at 2 Level-I trauma centers from 2006-2015. Patients were grouped into 2 categories: acutely diagnosed syndesmotic injury and missed syndesmotic injury. Acutely diagnosed syndesmotic injury was based on positive intraoperative manual stress examination. Missed syndesmotic injury was based on standing ankle radiographs demonstrating absent tibiofibular overlap with lateral talar subluxation or postoperative CT scan demonstrating syndesmotic malreduction. Fracture characteristics including Chaput and Volkmann fragment size, logsplitter injury, fibula avulsion fracture, Chaput malreduction, and ligamentous syndesmotic disruption were recorded.

Results: During the study period, 705 tibial plafond fractures were treated. 105 fractures in 102 patients (105 of 705, 15%) had a syndesmotic injury. 91 syndesmotic injuries (87%, 91 of 105) were diagnosed acutely. 14 fractures (14 of 705, 13%) had a missed syndesmotic injury. Volkmann fragment <10 mm and fibular avulsion fracture were significantly more common in missed syndesmosis injuries. Of the 105 fractures, 83 fractures (14 of 14 missed, 69 of 91 acute) had >12 months follow-up (mean 26 months; range, 12-102). Overall deep infection rate was 19% (16 of 83), and 13 fractures developed nonunion (13 of 83, 16%). All patients with missed syndesmosis injury developed moderate or end-stage PTOA, and 40% (33 of 83) of plafond fractures with acute syndesmosis injury developed moderate or end-stage PTOA. Patients who received syndesmotic fixation with either <10 mm Chaput or Volkmann fragment and/or distal fibular avulsion fracture were less likely to develop PTOA than if they had a similar pattern fracture without syndesmotic fixation (7 of 31 vs 10 of 10, P <0.01).

Conclusion: Syndesmotic disruption was identified in 15% of tibial plafond fractures. Patients with missed syndesmotic injury are likely to develop moderate to severe PTOA. For tibial plafond fractures with Chaput fragment <10 mm, Volkmann fragment <10 mm, and/or distal fibular avulsion fracture, the authors recommend syndesmotic fixation.

See pages 401 - 442 for financial disclosure information.

Computerized Adaptive Testing in Ankle Fracture Surgery

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Purpose: The goal of this study was to compare the legacy patient-reported measures used in foot and ankle surgery to the Patient Reported Outcomes Measurement Information System (PROMIS) scores in terms of ability to detect clinically significant differences.

Methods: Patients who underwent osteosynthesis for an unstable ankle fracture completed legacy outcome scores as well as the PROMIS Physical Function (PROMIS PF) and PROMIS Lower Extremity (PROMIS LE). Patients also completed the Olerud and Molander (O&M), the Weber score, and the Foot and Ankle Outcome Score (FAOS). Patients also electronically completed the PROMIS PF and PROMIS LE. Clinically significant outcome improvement was determined using the minimal clinically important difference (MCID).

Results: A total of 169 patients were analyzed at 310 total follow-up visits. Correlations between PROMIS and legacy measures are listed in Table 1. Smaller changes in outcome score were required to achieve clinically significant change on the PROMIS. Clinically significant changes in the PROMIS LE score were detected in patients between their 6-month and 12-month postoperative visit (P = 0.0019), whereas the reported O&M and Weber scores did not significantly differ between the 6-month and 12-month visit (P = 0.11) (Table 2).

Conclusion: PROMIS LE has enhanced ability to distinguish clinically significant changes in patients between time points following surgery. The PROMIS LE requires relatively smaller changes in order to detect meaningful outcome improvement and continues to detect clinical improvements out to 12 months.

Table 1. Correlation between PROMIS and Olerud&Molander; FAOS, Weber Ankle Scores

Measures	Correlation (rho)	p-value	R^2	
PROMIS LE – O&M	0.22	0.0026	0.0096	N=187
PROMIS LE-Weber	0.72	<0.001	0.53	N=187
PROMIS LE-FAOS Symptoms	0.56	<0.001	0.32	N=277
PROMIS LE-FAOS ADLs	0.73	<0.001	0.42	N=277
PROMIS LE-FAOS Quality of Life	0.71	<.001	0.52	N=274
PROMIS LE-FAOS Pain	0.69	<0.001	0.45	N=276
PROMIS LE-FAOS Sports	0.72	<.001	0.50	N=218

Table 2: MCID and Difference in Ankle Outcome Scores from 6-months to 12-months post-surgery

Score	MCID	Difference between 6-12 month	p-value
PROMIS PF	4.67	1.69	P=0.33
PROMIS LE	**3.97**	**4.04**	**P=0.0019**
Weber	9.38	3.88	P=0.124
Olerud & Molander (O&M)	11.46	3.33	P=0.11

Measuring Outcomes Over Time in Tibial Plafond Fractures: A Comparison of Generic, Musculoskeletal-Specific, and Foot and Ankle-Specific Outcome Measures

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Purpose: The standard in measuring results of treatment in orthopaedic trauma are the validated functional outcome measures. New outcome measures are often tailored to a specific disease, theoretically improving the ability to detect change in the disease compared to generic measures. Most new functional outcome measures are tested for validity and reliability, but not responsiveness, or the ability to detect clinical change over time. This prospective study compared the responsiveness of a generic (Short Form-36 Physical Component Summary, SF-36 PCS), a musculoskeletal-specific (Short Musculoskeletal Function Assessment Disability Index, SMFA), and foot and ankle-specific (Foot and Ankle Outcome Score Activities of Daily Living, FAOS) outcome score when evaluating surgically treated tibial plafond fractures over time.

Methods: This prospective study evaluated 51 patients who received operative intervention for a tibial plafond fracture. The SF-36, SMFA, and FAOS outcome measures were collected at baseline, 6 months, and 12 months post injury. Responsiveness was calculated through the standard response mean (SRM), the proportion meeting a minimal clinically important difference (MCID), and floor and ceiling effects. Statistical analysis comparing outcome scores was assessed through paired t test for SRM, McNemar's test for MCID, and a threshold of 10% for floor and ceiling effect.

Results: The SRM of the SF-36 was significantly greater than the SMFA and FAOS between baseline and 6 months ($P < 0.01$, $P = 0.02$). Between 6 and 12 months, the SRM of SF-36 was significantly greater in magnitude than the SMFA ($P = 0.02$), but was not significantly different from the FAOS. The proportion of patients achieving MCID for SF-36 PCS was consistently higher than SMFA and FAOS between baseline and 6 months ($P = 0.04$, $P = 0.03$). However, between 6 and 12 months, there was no significant difference between the 3 scores. No floor or ceiling effects were observed for the SF-36. The FAOS showed significant ceiling effects at baseline (84.3%) and at 12 months (11.3%).

Conclusion: This study shows that the SF-36 has greater responsiveness in assessing tibial plafond fractures compared to the SMFA and FAOS, particularly in the first 6 months. Despite the belief that musculoskeletal and anatomy-specific scores are a superior outcome measure to generic scores, limitations were revealed in the SMFA and FAOS. This supports the use of the generic outcome measure SF-36 in assessing patient recovery following tibial plafond fractures.

See pages 401 - 442 for financial disclosure information.

Prophylaxis of Venous Thromboembolism in Patients with a Nonsurgical Fracture of the Lower Extremity Immobilized in a Below-Knee Plaster Cast: A Randomized Controlled Trial

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Purpose: Immobilization of the lower leg is associated with deep vein thrombosis (DVT). However, thromboprophylaxis in patients with a below-knee plaster cast remains controversial. We examined the efficacy and safety of nadroparin and fondaparinux in patients immobilized in a below-knee plaster cast.

Methods: The PROTECT (Prophylaxis of Thromboembolism in Critical Care Trial) study was a multicenter study that enrolled adults with a fracture requiring below-knee immobilization. Participants were randomized for either the control group or one of the intervention groups: daily subcutaneous self-injection of either nadroparin (2850 IE anti-Xa = 0.3 mL) or fondaparinux (2.5 mg = 0.5 mL). A venous duplex sonography was performed after removal of the cast or earlier if thrombosis was suspected. Primary outcome was the relative risk of developing DVT in the control group compared with that in both intervention groups.

Results: 467 patients were enrolled and assigned to either the nadroparin group (n = 154), the fondaparinux group (n = 157), or the control group (n = 156). A total of 273 patients (92, 92, and 94 patients, respectively) were analyzed. The incidence of DVT in the nadroparin group was 2 of 92 (2.2%) compared with 11 of 94 (11.7%) in the control group, with a relative risk of 5.4 (95% confidence interval [CI] 1.2 - 23.6; P = 0.011). The incidence of DVT in the fondaparinux group was 1 of 92 (1.1%), yielding a relative risk of 10.8 (95% CI 1.4 - 80.7; P = 0.003) compared with that in the control group.

Conclusion: Thromboprophylaxis with nadroparin or fondaparinux significantly reduces the risk of DVT in patients with an ankle or foot fracture who were treated in a below-knee cast without any major adverse events.

Determinants of Functional Outcomes Following Ankle Fracture

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Purpose: The purpose of this study was to determine factors, including injury patterns, social factors, demographic variables, and treatment course, that may be associated with poor functional outcomes after ankle fracture.

Methods: 781 patients treated for ankle fractures over 4 years were studied to determine what patient variables (age, gender, body mass index [BMI], medical comorbidities), social factors (alcohol, smoking, drug use), injury factors (presence of dislocation, open fractures, pattern), and sequelae affect functional outcomes. Functional outcomes included Foot Function Index (FFI) and Short Musculoskeletal Function Assessment (SMFA) questionnaires. Higher scores indicate worse outcomes.

Results: 378 men and 405 women with mean age 41 and 48 years ($P < 0.0001$), were studied after mean 90.2 months. Women had worse SMFA Daily Activity (33.6 vs 25.6, $P < 0.05$) and SMFA Bothersome scores (32 vs 24.5, $P < 0.05$). BMI was associated with worse FFI ($B = 0.207$, $P = 0.007$), and BMI >40 was a threshold for worse FFI (4.4 vs 3.2, $P = 0.04$). Alcohol and drug use were significant predictors of worse outcomes: alcohol with worse SMFA Emotion (40.7 vs 30.2, $P = 0.007$), SMFA Mobility (46.7 vs 35.8, $P = 0.015$), SMFA Dysfunction (33.5 vs 26.0, $P = 0.03$), and SMFA Bothersome scores (33.4 vs 24.2, $P = 0.016$) and recreational drug use with worse FFI (4.9 vs 3.3, $P = 0.02$) and SMFA ($P < 0.05$). Fracture pattern, associated dislocations, and open fractures did not have association with outcomes. Complications (wound infections, malunions, nonunions) occurred in 8.2%, 1.3%, and 3.4% of patients, respectively, and were associated with worse FFI (4.8 vs 3.1, $P = 0.001$), SMFA Daily Activity (39.1 vs 27.3, $P = 0.03$), and SMFA Dysfunction (36.9 vs 27.4, $P = 0.03$), although posttraumatic arthritis did not affect functional outcomes.

Conclusion: Morbid obesity, female sex, and alcohol or recreational drug use were each independently associated with worse FFI scores and SMFA scores after ankle fractures. Complications were also associated with worse scores. In comparison, fracture pattern, dislocations, open fractures, and posttraumatic arthritis did not affect functional outcomes after mean 7.5-year follow-up.

See pages 401 - 442 for financial disclosure information.

Posterior Malleolar Fracture Morphology Determines Outcome in Rotational Type Ankle Fractures: A Prospective Clinical Trial

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Purpose: Rotational type ankle fractures with a concomitant fracture of the posterior malleolus are associated with a poorer clinical outcome compared to ankle fractures without. However, clinical implications of posterior malleolar fragment morphology and pattern have yet to be established. Many studies on this subject report on fracture size, rather than fracture morphology. The purpose of this prospective cohort study was to analyze whether morphology of the posterior malleolar fragment, based on CT quantification, is associated with functional outcome. We hypothesize that there is no difference in outcome between the different types of posterior malleolar ankle fractures.

Methods: From 2009 to 2014 ankle fractures at our Level I trauma center were prospectively included and characterized using pre- and postoperative CT scans as part of the EF3X-study protocol. 73 patients treated operatively for ankle fractures with a posterior malleolar fracture were classified according to Haraguchi: 20 type I fractures, 21 type II, and 32 type III. The Foot and Ankle Outcome Score (FAOS) and Short Form-36 (SF-36) at 12 weeks, 1 year, and 2 years postoperative were obtained. Statistical analysis included a multivariate regression analysis and a secondary mixed model analysis.

Results: Haraguchi type II compared to Haraguchi type I and III posterior malleolar ankle fractures demonstrated significantly poorer outcome scores during and at 2 years of follow-up. Mean FAOS domain scores at 2-year follow-up were significantly worse in Haraguchi type II as compared to type III, respectively: Symptoms 48.2 versus 61.7 ($P = 0.03$), Pain 58.5 versus 84.4 ($P = 0.001$), and Activities of Daily Living 64.1 versus 90.5 ($P = 0.001$).

Conclusion: Posterior malleolar fractures with medial extension (Haraguchi type II) are associated with a significantly poorer functional outcome. The current dogma to fix posterior malleolar fractures that involve at least 25% to 33% of the tibial plafond may be challenged, as posteromedial fracture pattern and morphology, rather than posterior malleolar fragment size, seem to determine outcome.

Assessing Quality of Reduction After Acetabular Fracture Surgery: Importance of Gap Versus Step Displacement

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Purpose: Our objective was to identify CT-based cut-off values for gap and step displacement associated with conversion to total hip arthroplasty (THA) and to determine the individual association of residual gap versus step displacement and hip survivorship following acetabular fracture surgery.

Methods: Patients who received acetabular fracture fixation (1992-2014) with ≥2-year follow-up (or early THA) and postoperative CT available for review were included, which yielded 227 patients (mean age 51. 2 years [SD 17.8], 46.3% <50 years, mean follow-up 8.7 years [SD 5.6]). Conversion to THA was performed in 55 patients (24.2%). Residual gap and step displacement was measured in axial, sagittal, and coronal planes using a standardized CT-based method. Receiver operating characteristic and Kaplan-Meier survivorship curves and log-rank tests were used to assess statistical differences in hip survivorship curves between gap and step displacement using the respective cut-off values. Multivariate analysis was performed to identify independent variables associated with conversion to THA. A subanalysis was performed in younger patients (<50 years).

Results: The optimal CT cut-off value associated with conversion to THA was 5 mm for gap and 1 mm for step displacement. Hip survivorship at 10 years was 82.0% for patients with <5 mm gap and 56.5% for patients with ≥5 mm gap, and hip survivorship curves were significantly different (P <0.001). Similarly, 10-year hip survivorship was 80.0% for patients with step <1.0 mm and 65.5% for patients with step ≥1.0 mm, and hip survivorship curves were significantly different (P = 0.012). In all patients, age ≥50 years (P = 0.001; odds ratio [OR] 3.7, 1.7-7.8), gap ≥5 mm (P = 0.004; OR 3.1, 1.4-6.7), and posterior wall impaction (P = 0.037; OR 2.1, 1.1-4.4) were independently associated with conversion to THA. In younger patients, only step ≥1 mm was independently (P = 0.046; OR 5.4, 1.1 – 28.8) associated with conversion to THA.

Conclusion: Both residual gap and step displacement are associated with hip survivorship. However, CT cut-off values show that step is tolerated less (1 mm) than gap displacement (5 mm). Only greater gap (≥5 mm) displacement is independently associated with conversion to THA in all patients. Our findings are likely influenced by the large proportion of older patients with significant residual gaps in our study. In younger patients, it appears that only greater step (≥1 mm) displacement is associated with conversion to THA. Residual gap and step displacement after acetabular fracture surgery should be considered as 2 separate entities.

See pages 401 - 442 for financial disclosure information.

Outcome of Acetabular Fractures with a Posterior Dislocation

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Purpose: Acetabular fractures with a dislocation of the femoral head are a subgroup assumed to result in worse outcomes, but there are few studies documenting the natural history and long-term patient-reported outcomes. The aim of this study was to evaluate the clinical outcomes and complications following an acetabular fracture associated with a posterior hip dislocation.

Methods: Our unit provides definitive orthopaedic treatment for a catchment population of 1.2 million. Data on all patients admitted to the trauma unit are collected prospectively at time of presentation. We retrospectively reviewed database records for patient characteristics, complications, predictors of poor outcome, and requirement for further surgery. Long-term patient outcomes were measured using the Oxford hip score and Short Form-12 (SF-12) health survey.

Results: A total of 99 patients were treated. Internal fixation was performed in the majority (n = 87), 10 were managed conservatively, and 2 underwent primary arthroplasty. Following fixation a conversion to arthroplasty was required in 20% of cases at a median time of 2 years from injury. Increasing age was associated with conversion to arthroplasty (P = 0.049) and in a shorter length of time (P = 0.036). At a median follow up of 12.4 years (range, 5-25) patient-reported outcomes (n = 53) revealed both groups of patients had substantial disability with mean Oxford hip scores less than normal. In those patients who kept their native hip post injury only half of the cohort reported normal hip scores. Those conservatively managed had better hip scores than those post ORIF (open reduction and internal fixation), but this failed to reach significance (P = 0.13). Age at time of injury did not appear to influence the Oxford hip score. Hip scores were similar for patients before and after 10 years post injury (P = 0.76). There were no obvious differences between fracture classification subtypes. The mean Oxford hip score was similar between the native hip and conversion groups (P = 0.256). SF-12 scores were below average for both groups with the physical score more affected than the mental. The requirement for use of walking aids was high in both groups, with the majority (79%) in those converted to total hip arthroplasty (THA) requiring one.

Conclusion: Our study suggests that acetabular fracture dislocations are associated with poor functional outcomes and high conversion rate to THA. Increasing age is a strong predictor for secondary osteoarthritis following ORIF and in a shorter length of time. Recognition of high-risk patients for failure following ORIF may allow better selection for a combined acetabular reconstruction and THA given the poor patient-reported outcomes we found after secondary conversion to arthroplasty.

The Longitudinal Short, Medium, and Long-Term Functional Recovery After Unstable Pelvic Ring Injuries

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Purpose: Unstable pelvic injuries are associated with considerable morbidity and prolonged disability. The expected arc of recovery following surgical treatment is valuable information but remains unknown. Several studies have reported on single time-point outcomes and their prediction, but to our knowledge no prospective study has followed a single patient group over multiple time points long term. The aim of this prospective study was to describe the trajectory of recovery for surgically treated unstable pelvic ring injuries from baseline to 5 years from the date of surgery.

Methods: Adults with surgically treated pelvic ring injuries (OTA B,C) were prospectively enrolled at a Level I trauma center between 2004 and 2015. Functional recovery was recorded at baseline and prospectively at 6 months, 1 year, and at 5 years postoperatively using the Short Form- 36 Physical Component Summary score (SF-36 PCS). The trajectory of functional recovery was mapped, and means between time points were compared. The proportion of patients that achieved a Minimal Clinically Important Difference (MCID) between time points was calculated. A subgroup analysis stratifying OTA Type B and C injuries was performed.

Results: The cohort was composed of 108 patients, 72% B-type (OTA 61 B1-B3) and 28% C-type (OTA 61 C1-C3). The cohort was 78% male with a mean age of 44.9 years and ISS of 16.9. The ISS of Type B and C injuries were similar ($P = 0.24$). The mean SF-36 PCS improved for the entire group between 6 and 12 months ($P = 0.001$) and between 1 and 5 years ($P = 0.02$), but did not return to baseline at 5 years ($P < 0.0001$). The proportion of patients achieving an MCID between 6 and 12 months and 1 and 5 years was 75% and 60%, respectively. Functional level was similar between Type B and C groups at baseline ($P = 0.5$) and 6 months ($P = 0.2$); however, the Type B cohort reported higher functional scores at the 1-year ($P = 0.01$) and 5-year ($P = 0.01$) marks. Neither group regained their baseline function ($P < 0.0001$).

Conclusion: The trajectory of functional recovery for patients with surgically treated pelvic ring injuries is characterized by an initial decline in function, followed by sharp improvement between 6 and 12 months, and continued steady improvement between 1 and 5 years. Patients with Type B injuries show better early recovery than Type C injuries, and reach a higher level of function at the end of follow-up. Despite the proportion achieving an MCID improvement up to 5 years, patients do not regain preinjury level of function.

See pages 401 - 442 for financial disclosure information.

Preperitoneal Pelvic Packing for Acute Hemorrhage Control Is Not Associated with an Increased Risk of Infection After Anterior Pelvic Ring Fixation

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Purpose: Preperitoneal pelvic packing (PPP) represents a fast and effective measure of acute hemorrhage control in hemodynamically unstable pelvic ring disruptions. The risk of an increased postoperative infection rate after internal pelvic ring fixation subsequent to pelvic packing/depacking remains an area of concern among orthopaedic trauma surgeons. We hypothesized that PPP would not result in an increased surgical site infection rate after anterior pelvic ring fixation.

Methods: A retrospective observational cohort study was performed during a 5-year study time window from January 1, 2011 until December 31, 2015 at an academic Level I trauma center that uses PPP as the standard primary intervention for early bleeding control in hemodynamically unstable pelvic ring disruptions. The primary outcome measure was the rate of surgical site infections after definitive pelvic ring fixation. Secondary outcome measures included other orthopaedic complications and unplanned surgical revisions. This study was approved by the IRB.

Results: A total of 61 patients with hemodynamically unstable pelvic ring disruptions underwent "damage control" external pelvic fixation and PPP for acute hemorrhage control during the 5-year time window. Two patients aged <18 years were excluded. The median ISS in the included 59 patients was 43 (45 ± 12.3 mean ± SD; range, 20-75). The median time until pelvic depacking was 2 days (1.7 ± 0.7 mean ±SD; range, 1-3 days). The median time from depacking until definitive internal pelvic ring fixation was 3.5 days (4.9 ± 4.4 mean ± SD; range, 0-16 days). Two patients had a postoperative surgical site infection after pelvic ring fixation (3.4%) that required surgical debridement, implant removal, and antibiotic management. Seven patients died from their injuries during the initial hospitalization (postinjury mortality rate: 11.9%). Of these, only 1 patient died from acute exsanguination (1.7%). The overall rate of orthopaedic complications requiring a surgical revision was 10.2%.

Conclusion: Pelvic packing and subsequent depacking within 2 days is associated with a low postoperative surgical site infection rate after delayed internal pelvic ring fixation of 3.4%, which is in a similar range of the published historic benchmark of 3% to 21% in the literature on postoperative infections after pelvic ring fixation without pelvic packing. These data support the safety aspect of the PPP protocol for acute bleeding control in hemodynamically unstable pelvic ring injuries.

Contrast Blush on CT Is a Poor Predictor of Active Bleeding on Pelvic Angiography

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Purpose: Angiographic embolization is the therapeutic intervention of choice for massive pelvic hemorrhage. Contrast extravasation (CE) on CT, or CT blush, is a widely used indication for pelvic angiography. We hypothesize that in isolation, CE is not a reliable predictor of clinically relevant arterial bleeding in patients with pelvic trauma.

Methods: 189 patients over 16 years underwent angiography for pelvic ring injury. Demographic and injury data, including Young-Burgess classification (YB), ISS, Glasgow Coma Scale (GCS), hypotension (persistent systolic blood pressure <90 mm Hg), and heart rate upon presentation were recorded. CE on CT scan was noted. Angiographic findings were classified as either active bleeding or none.

Results: Mean age was 49 years, with 64% male. Indications for angiography included: hypotension (n = 118, 72.4%), CE (n = 112, 61%), anteroposterior compression (APC) pattern, and vital signs unresponsive to resuscitation. CE was reported in 112 patients (61%), with increasing frequency over the study period. Patients under age 55 were less likely to have CE on CT (55.4% vs 83.6%, P <0.001). GCS was higher and ISS lower in patients with CE (P <0.05). Other characteristics, such as mechanism, YB pattern, and mortality, were not different for patients with and without CE. When investigating CE as a predictor of active bleeding, sensitivity was 66.7%, specificity was 33.8%, positive predictive value (PPV) was 57.7%, and negative predictive value (NPV) was 57.1% with P = 0.95. For CE as a predictor of overall mortality, the sensitivity, specificity, PPV, and NPV were 66.7%, 33.3%, 16.1%, and 16.1%, respectively, with P = 1.0. Hypotension predicted active bleeding with sensitivity 83%, specificity 40%, PPV 61.9%, and NPV 33.3% (P = 0.001). Furthermore, hypotension sensitivity, specificity, PPV, and NPV for predicting overall mortality were 96.7%, 33.1%, 24.6%, and 2.2%, respectively, with P = 0.001.

Conclusion: Contrast extravasation was neither sensitive nor specific for active bleeding. Alternatively, hypotension was a better indicator for pelvic angiography, with sensitivity of 67% for active bleeding. Over the study period there was more CE reported, potentially due to greater detail of modern CT scanner technology. These findings suggest that CE is not independently a sufficient indication for pelvic angiography. CE may present more often in older patients with less alarming sources of arterial bleeding. Eliminating pelvic angiography when CT blush is the only indication would prevent unnecessary interventions, reduce costs, and ease patient burden.

See pages 401 - 442 for financial disclosure information.

Does Reduction Technique for Pelvic and Acetabular Injuries Affect Trauma-Induced Coagulopathy? A Prospective Cohort Study

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Purpose: Pelvic and acetabular injuries are associated with venous thrombotic events (VTEs). Operative reduction may be achieved with closed or open techniques. The effect that magnitude of surgical approach has on trauma-induced coagulopathy (TIC) is unknown. Coagulopathy can be assessed with rapid thrombelastography (r-TEG), specifically the maximal amplitude (mA). The null hypothesis was no difference in mA 24 hours after surgery between patients treated with closed versus open reduction techniques for pelvic and acetabular injuries.

Methods: After obtaining IRB approval, patients 18-65 years of age with operative pelvis or acetabular injuries (OTA/AO 61-A,B,C and 62-A,B,C) were screened for enrollment and excluded for existing coagulopathic states, severe burns, failure to consent for the study, and delayed presentation. 51 patients, 23 in the closed reduction group (CR group) and 28 in the open reduction group (OR group), were enrolled. r-TEG was performed on admission, 1 hour preoperatively, 1 hour postoperatively, and at 24 hours postoperatively and used to evaluate changes in mA. Statistical comparisons were performed using the Student t test.

Results: No difference in age, sex, body mass index, Glasgow Coma Scale, ISS, or time from admission to surgery between the CR and OR groups (all $P > 0.23$) existed. A significant increase in hypercoagulability from preop (mA 67.26 ± 6.4) to 24 hours postop (mA 71.04 ± 5.7) ($P = 0.04$) was seen in the CR group. An insignificant decrease in mA from preop (mA 70.64 ± 5.4) to 24 hours postop (mA 70.04 ± 4.4) ($P = 0.65$) was observed for the OR group. The difference between the ΔmA (+3.78) at 24 hours of the CR group and OR group (-0.60) was statistically significant ($P < 0.01$). One hour preoperatively the OR group was more hypercoagulable (CR = 67.26 vs OR = 70.64, $P = 0.049$). No significant differences existed at the other time points in either group.

Conclusion: Counterintuitively, patients treated with closed reduction became more hypercoagulable 24 hours postoperatively than those treated with open reduction. Increased blood loss with open techniques may induce transient hypocoagulability. The relationship with venous thromboembolic disease awaits further investigation.

Percutaneous Transiliac-Transsacral Fixation of Sacral Insufficiency Fractures Improves Ambulation and Rate of Disposition to Home

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Purpose: With the increasing geriatric population, sacral insufficiency fractures are becoming more prevalent. While these fractures are typically stable and do not meet absolute surgical indications, they can cause significant pain and inability to ambulate. In this vulnerable population with multiple comorbidities, this can lead to complications as well as the need for nursing home placement. The purpose of this study is to determine whether percutaneous sacral fixation improves ambulation and the rate of disposition to home after admission.

Methods: All low-energy, isolated sacral insufficiency fractures over a 1-year period from August 1, 2015 to August 1, 2016 at a single academic institution were reviewed. Exclusion criteria included high-energy mechanism, age <60 years, presence of other injury or medical condition preventing ambulation, inability to ambulate prior to injury, living in a facility prior to injury, and presence of an unstable sacral fracture meeting absolute surgical indications. All patients underwent a trial of conservative management with physical therapy and pain medication. If unable to ambulate or severe posterior pelvic pain with ambulation was present, patients were offered percutaneous transiliac-transsacral screw fixation of their sacral fracture.

Results: 41 patients were included in the study, of whom 16 underwent surgery and 25 were treated nonoperatively. Preoperative characteristics including age, gender, and Charlson Comorbidity Index scores were similar between the 2 groups. Of the patients treated operatively, 12 of 16 (75%) were discharged to home, compared to 5 of 25 (20%) in the nonoperative group (P = 0.0009). All of the patients treated operatively were able to ambulate on postoperative day 1, compared with only 18 of 25 (72%) of the nonoperative patients being able to ambulate at any point during their admission. Average surgical time was 34 ± 15 minutes, and there were no intraoperative or postoperative complications related to surgery. Length of stay was similar between the 2 groups (4.0 days in operative group vs 4.2 days in nonoperative group).

Conclusion: Percutaneous transiliac-transsacral screw fixation of sacral insufficiency fractures leads to improved ambulation and an increased rate of disposition to home. Surgery should be offered to patients who fail to ambulate with physical therapy and to those with severe posterior pelvic pain with ambulation.

See pages 401 - 442 for financial disclosure information.

Fixation Strategy Using Sequential Intraoperative Examination Under Anesthesia for Unstable Lateral Compression Pelvic Ring Injuries Reliably Predicts Union with Minimal Displacement

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Purpose: EUA has been used to identify pelvic instability. Surgeons may use percutaneous methods to fix the posterior and anterior pelvic ring in unstable lateral compression (LC) pelvic injuries, but no criteria exist to guide fixation strategy. A strategy has been developed to perform stepwise fixation and reassessment with sequential EUA. Our aim was to determine whether a fixation strategy based on sequential intraoperative EUA reliably results in union with minimal displacement.

Method: A multicenter retrospective review of all skeletally mature patients with a closed LC pelvic injury treated from 2013 to 2016 was completed. Inclusion included skeletally mature patients, pelvic CT, percutaneous fixation, and patients who underwent sequential EUA. Data included demographics, fracture pattern, associated injuries, screw type (fully and partially threaded), number and type of posterior screws (iliosacral versus transiliac transacral), intraoperative distraction frame, postoperative weight bearing, displacement measured on postoperative radiographs, and length of follow-up. Statistical analysis was completed using Pearson uncorrected chi-square test. $P < 0.05$ was considered statistically significant.

Results: Complete data was available in 74 patients. Mean age was 41 yrs (range, 14-77) and follow-up 11 mos. 53 patients (71.6%) had LC-1 injuries, 19 (25.6%) had LC-2 injuries, and 2 (2.7%) had LC-3 injuries. 25 of 53 patients (47.1%) with LC-1 and 11 of 19 (57.9%) with LC-2 injuries did not receive anterior fixation based upon the algorithm. The 36 LC-1/LC-2 patients who received anterior and posterior fixation had no measurable displacement at union. Of the remaining 36 LC-1/LC-2 patients with no anterior fixation, 27 with unilateral ramus fractures had no measureable displacement at union. The remaining 9 LC-1/LC-2 patients with no anterior fixation had bilateral superior ramus fractures; each of these 9 patients demonstrated a mean displacement of 7.5 mm (range, 5-12) within 6 weeks of fixation that remained until union ($P < 0.0001$). Of the LC-3 injuries, one patient had a unilateral superior ramus fracture and no anterior fixation was placed predicated on the algorithm; the patient healed with no displacement. The remaining patient with an LC-3 injury had anterior ring fixation and healed with no displacement.

Conclusion: A fixation strategy based on sequential intraoperative EUA reliably results in union with minimal displacement for unstable LC pelvic ring injuries.

Unstable Pelvic Ring Injuries: How Soon Can Patients Safely Bear Weight?

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Purpose: Surgical intervention for pelvic ring injuries attempts to restore pelvic ring alignment and stability while allowing for patient mobilization. Patients are often instructed to follow modified weight-bearing protocols for a period of time following surgery. The aim of this study was to determine the effect the time of restricted weight bearing had on final alignment and union of unstable pelvic ring injuries.

Methods: A retrospective review was performed to identify all patients with operatively treated unstable pelvic ring injuries over 10 years. Patient charts were reviewed to determine injury mechanism, fracture pattern (Young-Burgess classification), fixation construct, and postoperative weight-bearing protocols. Postoperative complications were noted including: implant failure, revision surgery, and malunion (5 mm of displacement of the hemipelvis or pubic symphysis in a nonanatomic position). Patients were included in the study if they had a 6-month follow-up with documented pelvic radiographs. Patients with associated injuries prohibiting postoperative mobilization were excluded. Patients were stratified into early (≤8 weeks) and late (>8 weeks) time to full weight-bearing groups.

Results: We identified 286 patients meeting our inclusion criteria with mean age was 39.9 years and average follow-up of 1.2 years (range, 0.5-9 years). There were 132 and 154 patients in the early and late weight-bearing groups respectively. There were 142 lateral compression type (LC)-1, 48 LC-2, 23 LC-3, 10 anterior posterior compression (APC)-1, 45 APC-2, 8 APC-3 injuries, and 8 vertical shear injuries. Complications included: 18 implant failures, 16 malunions, and 13 patients who required revision operations. There were 17 (13%) complications in the early weight-bearing group as compared to 30 complications (19%) in the late weight-bearing group ($P = 0.24$). Irrespective of time to weight bearing, APC-2, LC-3, and any LC fracture pattern with associated bilateral rim fractures were noted to have higher complication rates ($P = 0.007$, 0.03, 0.024, respectively) than the rest of the cohort.

Conclusion: We were unable to demonstrate a difference in implant failure, malunion, or early loss of reduction between operatively treated pelvic ring injuries allowed to weight-bear as tolerated before 8 weeks compared to those who remained on protected weight bearing for any time greater than 8 weeks. These data may provide information to support early weight-bearing protocols in pelvic ring injuries.

See pages 401 - 442 for financial disclosure information.

Comparison of PROMIS to Legacy Patient-Reported Outcome Scores in Upper Extremity Trauma

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Purpose: The objective of this study was to compare the Patient Reported Outcomes Measurement Information System (PROMIS) to legacy PRO scores in patients following surgery for upper extremity fractures in terms of correlation as well as floor and ceiling effects.

Methods: Patients who underwent open reduction and internal fixation of the distal radius, elbow, humeral shaft, proximal humerus, and clavicle fractures between 2015 and 2016 were enrolled in the study. At follow-up appointments, patients were asked to first complete the visual analog scale (VAS) for pain, the Disabilities of the Arm, Shoulder and Hand (DASH), and the Short Form-36 (SF-36). Upon completion, the participants were then asked to complete PROMIS-Physical Function (PROMIS PF), PROMIS Bank-Pain Interference (PROMIS Pain), and PROMIS Upper Extremity (PROMIS UE). Correlations between the various outcome scores were calculated as well as the amount of floor and ceiling effect for each outcome.

Results: The outcomes scores of 174 patients were analyzed at 263 total time points. The correlation between the PROMIS PF and the legacy physical function outcome scores was high (SF-36 PCS to PROMIS PF rho = 0.70, P <0.001 and DASH to PROMIS PF rho = -0.71, P <0.001). PROMIS UE scores also correlated with the other PF outcome measure scores (SF-36 PCS to PROMIS UE rho = 0.61, P <0.001 and DASH to PROMIS UE rho = -0.76, P <0.001) (Table 1, Fig. 1). Significant ceiling effects were observed using both the DASH and the VAS outcomes, while the PROMIS PF, PROMIS Pain, and PROMIS UE displayed no ceiling effects.

Conclusion: In upper extremity trauma patients, the PROMIS was significantly correlated with legacy outcome scores including the DASH and the SF-36 with less ceiling and floor effects.

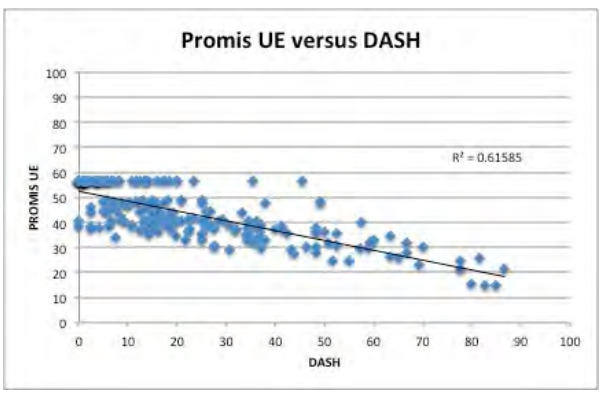

Table 1. Correlations between PROMIS and UE Specific Legacy Outcome Scores

Measures	Correlation (rho)	P	R2	
PROMIS PF CAT- UCLA	0.58	<0.001	0.31	N=74
PROMIS UE CAT- UCLA	0.59	<0.001	0.33	N=74
PROMIS PF CAT-Constant	0.48	<0.001	0.20	N=53
PROMIS UE CAT-Constant	0.46	<0.001	0.20	N=53
PROMIS PF CAT-Mayo	0.33	0.014	0.14	N=56
PROMIS UE CAT-Mayo	0.56	<0.001	0.40	N=56
PROMIS PF CAT - DASH	-0.71	<.001	0.47	N=235
PROMIS UE CAT - DASH	-0.76	<.001	0.62	N=235

Randomized, Placebo-Controlled Clinical Trial Evaluating Ketotifen Fumarate in Reduction of Posttraumatic Elbow Joint Contracture

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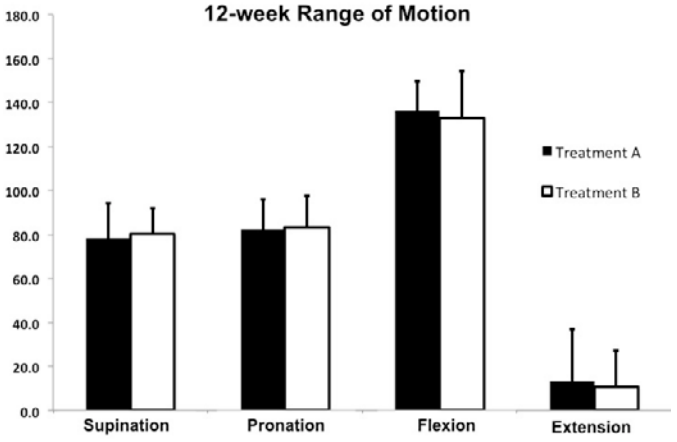
Purpose: Our research has established that a myofibroblast-mast cell-neuropeptide axis underlies the joint capsule fibrosis associated with posttraumatic joint contractures (PTJCs). In our rabbit model, ketotifen fumarate (KF), a mast cell stabilizer, decreased PTJCs by 50%, concomitant with decreased measures of fibrosis. This Phase II trial was designed to determine safety and feasibility of a Phase III trial for further clinical study of KF.

Method: A randomized, placebo-controlled clinical trial (RCT) comparing 6 weeks of oral KF 5 mg twice daily to a lactose placebo for distal humerus and proximal radius ± ulna fractures and/or dislocations. The primary outcome measure was flexion-extension range of motion (ROM) at 12 weeks post-injury. Secondary outcomes included DASH score, complications, and fracture healing. Subgroup analysis compared operative with nonoperative treatment. Statistical analysis consisted of chi-square for categorical variables and ANOVA for continuous variables. Multiple linear regression was used to assess the adjusted effect of KF.

Results: 145 patients were randomized (76 KF, 69 placebo). More patients were treated nonoperatively (n = 80), at the discretion of treating surgeons. There was no difference between the mean age (46.7 ± 18.3 years for KF vs. 44.4 ± 13 years for placebo), sex (54% female for KF vs. 42% for placebo), side of injury, hand dominance, pre-injury work status, time from injury to randomization (mean 3.7 days), injury classification, and surgical treatment (45% in each group); all $p > 0.05$. 12-week follow-up rate was 88% in the KF group and 89% in the placebo group. There was no significant difference between treatment groups for 12-week ROM, DASH, adverse events, or reoperation rate; all $p > 0.05$. There was a significant decrease in ROM in the operative subgroup ($p = 0.03$). Fracture union was 48% in each group at the time of analysis.

Conclusion: This Phase II RCT was completed successfully with adequate follow-up and several measures confirmed the safety of KF. Patients requiring surgical treatment demonstrated increased PTJC. There were more patients treated nonoperatively; therefore, it is possible that a lower likelihood of developing PTJC (due to lower injury severity) may have masked the full treatment effect of KF. The greater loss of motion at 12 weeks in the operative subgroup will inform the Phase III multicenter injury inclusion criteria to elbow fractures or dislocations requiring surgery.



See pages 401 - 442 for financial disclosure information.

Radial Nerve Injury and Recovery After Humeral Nonunion Surgery

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Purpose: Radial nerve palsy(RNP) after humeral shaft fractures is well characterized. Data regarding RNP after humeral nonunion repair is more limited and rates range from 0% to 18.5%, typically from small sample sizes. This study uses multi-center data to determine the rate of RNP after humeral nonunion repair and predictive factors for palsy.

Methods: We retrospectively reviewed 393 adult patients who underwent humeral shaft nonunion repair at 18 centers. Exclusion criteria were pathologic fracture and initial complete RNP. Data included demographics, fracture/nonunion characteristics, and post-op course. RNP deficits either partial or complete. We used multivariate logistic regression to characterize patients with RNP. Additionally, demographics and surgical factors were evaluated with univariate logistic regression and chi-squared contingency testing.

Results: 393 patients (159 M, 234 F, ages 18-93). 25(6.3%) had worse RNP after nonunion repair. 68% were approached anteriorly with a 6% palsy rate, 8% posteriorly with 5% and 7% laterally with 8%. Midshaft nonunions were associated with RNP($P = 0.02$) and bone grafting trended towards association ($P = 0.07$). Logistic multivariate regression showed good model performance for fracture location, nonunion type, and nonunion repair approach($P = 0.036$). Middle third fractures correlated with RNP($P = 0.02$). Of 25 patients with postop RNP, 8(32%) had persistent RNP at final follow-up (273 days; range 40-539). For those who recovered, resolution averaged 23 weeks. On average, partial/complete palsies resolved at 11/42 weeks.

Conclusion: In a large series of patients treated operatively for humeral shaft nonunion, the rate of RNP was 6.3% and the rate of persistent RNP at union was 2.0%. This finding is more generalizable than prior reports. Midshaft fractures were associated with palsy although surgical approach was not.

Minimally Displaced, Isolated Radial Head Fractures Do Not Require Formal Physical Therapy: Results of a Prospective Randomized Trial

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Purpose: Nondisplaced or minimally displaced radial head fractures (OTA Type 21A2.2) are common nonoperative elbow injuries. The role of physical therapy (PT) in the treatment of this injury is unclear. The aim of our prospective, randomized trial was to assess the need for formal PT following simple radial head fractures.

Methods: All eligible patients with nonoperative radial head fractures (with displacement <2 mm) presenting to 1 of 2 providers were consented and enrolled between January 2014 and August 2016. Patients were randomized to receive either prescribed outpatient PT or home exercise treatment with a standard set of self-directed exercises. Patients were followed up at 6 weeks, 3 months, 6 months, and 1 year. Outcome measures included Disabilities of the Arm, Shoulder and Hand (DASH) scores, time to clinical healing, and range of motion. Recorded range of elbow and wrist motion included flexion, extension, pronation, and supination. Data were analyzed using independent samples t tests and chi-squared analysis with a P value of <0.05 as significant.

Results: 51 patients enrolled with average follow-up of 15.1 months (15.1 ± 4.0). Of the 51 patients, 25 patients were randomized to a home exercise program and 26 patients were randomized to a formal outpatient PT program. These patients attended a mean of 7.6 ± 4.4 PT sessions. There were no differences in patient demographics between groups. At 6 weeks, patients utilizing home exercises reported greater function with a lower mean DASH score (7.4 ± 4.9) compared to the PT cohort (12.1 ± 8.4) (P = 0.021). There was no difference in arc of motion at 6 weeks. At 3 months, 6 months, and at final follow-up, there was no difference in mean DASH score or arc of motion between cohorts. There was no difference in time to clinical healing between groups. Two patients in the PT cohort and 1 in the home exercise cohort developed secondary lateral epicondylitis and were treated nonoperatively.

See pages 401 - 442 for financial disclosure information.

The Influence of Shortening on Clinical Outcome in Healed, Displaced, Midshaft Clavicle Fractures After Nonoperative Treatment

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Purpose: Radiographic malunion is always seen following nonoperative treatment of displaced midshaft clavicular fractures; however, the implications on clinical outcome remain unclear. We aimed to evaluate the effect of clavicular shortening, measured by 3-dimensional computed tomography (3DCT), on functional outcomes and satisfaction in patients with healed, displaced, midshaft clavicle fractures up to 1 year following injury.

Methods: The data used in this study were collected as part of a multicenter, prospective randomized control trial comparing open reduction and plate fixation with nonoperative treatment for acute displaced midshaft clavicle factures. Patients who were randomized to nonoperative treatment and who had healed by 1 year were included in the present study. Shortening relative to the uninjured contralateral clavicle was measured on 3DCT. A standardized protocol for measuring clavicle length was followed. The uninjured side served as a control and was deemed to have a relative length of 100%. The proportional shortening was measured as follows: PS, proportional shortening; FS, fractured side; US, uninjured side; PS [%] = [(US – FS)/US] × 100. Outcome analysis was conducted at 6 weeks, 3 months, 6 months, and 1 year following injury and included the Disabilities of the Arm, Shoulder and Hand (DASH), Constant, and Short Form-12 (SF-12) scores, and patient satisfaction.

Results: 48 patients with displaced midshaft clavicle fractures who healed following nonoperative treatment and who had a 3DCT scan that included the whole length of both clavicles were included. The mean shortening of injured clavicles, relative to the contralateral side, was 11.3 mm (±7.6 mm) with a mean proportional shortening of 8%. Proportional shortening did not significantly correlate with the DASH ($P > 0.42$), Constant ($P > 0.32$) or SF-12 ($P > 0.08$) scores at any point during follow-up. There was no significant difference in the mean DASH or Constant scores at any follow-up time point both when the cut-off for shortening was defined as 1 cm ($P > 0.11$) or 2 cm ($P > 0.35$). There was no significant difference in clavicle shortening between satisfied and unsatisfied patients ($P > 0.49$).

Conclusion: The present study demonstrated no association between shortening and functional outcome or satisfaction in patients with healed, displaced, midshaft clavicle fractures up to 1 year following injury.

Proximal Humeral Fracture Fixation Using the PH Cage:
A Retrospective Study of 125 Patients to a Minimum of 6 Months Post Treatment

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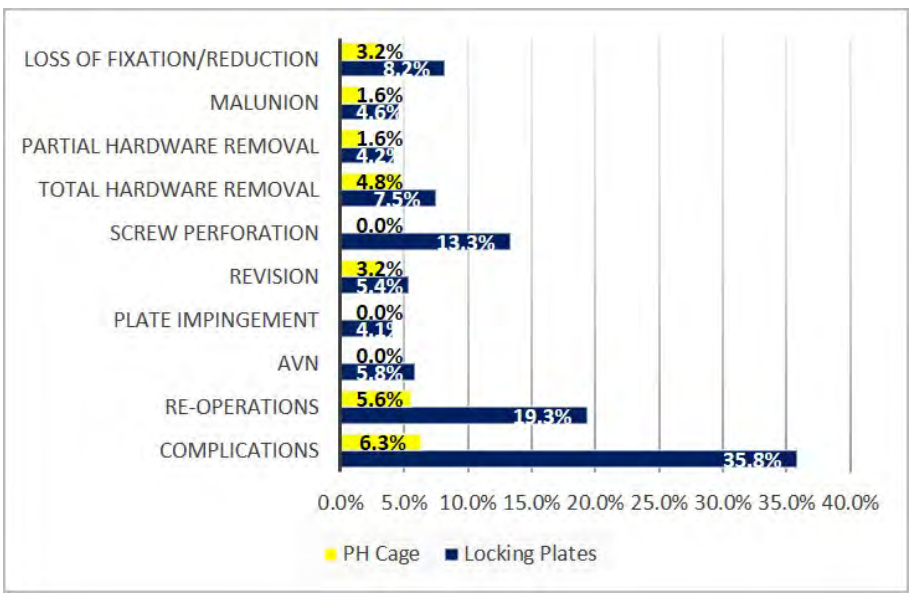
Purpose: Locking plates are commonly used for surgical fixation of proximal humeral (PH) fractures, but complication rates remain high. A new technology, termed PH Cage, uses an intramedullary implant to provide direct support to the humeral head. It allows the surgeon discretion with both the number and direction of screws needed to fix fractures. This is a retrospective study of PH Cage usage in 125 patients to a minimum 6 months of follow-up.

Method: A retrospective analysis of PH Cage was assessed for 125 patients to a minimum of 6 months following fracture fixation. Cases include 2-, 3-, and 4- part fractures. Surgical approaches used include deltopectoral, deltoid-splitting, or less invasive procedures. PH Cage complication rates are compared directly to a literature analysis of complication rates for locking plates compiled from 2100 patients in 27 publications.

Results: 125 PH fractures were treated in 125 patients using the PH Cage. Follow-up average of 11.3 months (range, 6.0-18.2) following fracture fixation of which 21.4% were male and 78.6% female. Average age was 64.1 years (range, 25-95). Fracture patterns: 30.6% 2-part, 41.3% 3-part, 26.4% 4-part, and 1.7% miscellaneous. Approaches: 69.8% deltopectoral approach, 4.3% deltoid split approach, 25.9% less invasive. Overall total complications and reoperations were 6.3% and 5.6% for PH Cage as compared to 35.8% and 19.3% respectively for locking plates.

Conclusion: The PH Cage is a novel technology used for the treatment of PH fractures. A retrospective analysis of 125 patients implanted to a minimum of 6 months with the PH Cage demonstrates a significantly lower incidence of total complications when compared to locking plates.



See pages 401 - 442 for financial disclosure information.

Reliability, Validity, Responsiveness, and Minimal Important Change of the Disabilities of the Arm, Shoulder and Hand and Constant-Murley Scores in Patients with a Humeral Shaft Fracture

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Purpose: The Disabilities of the Arm, Shoulder and Hand (DASH) and Constant-Murley scores are commonly used instruments. The DASH is patient-reported, and the Constant-Murley combines a clinician-reported and a patient-reported part. For patients with a humeral shaft fracture, their validity, reliability, responsiveness, and Minimal Important Change (MIC) have not been published. This study evaluated the measurement properties of these instruments in patients who sustained a humeral shaft fracture.

Methods: The DASH and Constant-Murley instruments were completed 5 times until 1 year after trauma. Pain score, Short Form-36, and EuroQol-5D were completed for comparison. Internal consistency was determined by the Cronbach α. Construct and longitudinal validity were evaluated by assessing hypotheses about expected Spearman rank correlations in scores and change scores, respectively, between patient-reported outcome measures (sub)scales. The Smallest Detectable Change (SDC) was calculated. The MIC was determined using an anchor-based approach. The presence of floor and ceiling effects was determined.

Results: A total of 140 patients were included. Internal consistency was sufficient for DASH (Cronbach $\alpha = 0.96$), but was insufficient for Constant-Murley ($\alpha = 0.61$). Construct and longitudinal validity were sufficient for both patient-reported outcome measures (>75% of correlations hypothesized correctly). The MIC and SDC were 6.7 (95% confidence interval [CI] 5.0-15.8) and 19.0 (standard error of measurement [SEM], 6.9), respectively, for DASH and 6.1 (95% CI, -6.8 to 17.4) and 17.7 (SEM, 6.4), respectively, for Constant-Murley.

Conclusion: The DASH and Constant-Murley are valid instruments for evaluating outcome in patients with a humeral shaft fracture. Reliability was only shown for the DASH, making this the preferred instrument. The observed MIC and SDC values provide a basis for sample size calculations for future research.

Volar Plate Fixation Versus Plaster in Extra-Articular Distal Radius Fractures: A Prospective Multicenter Randomized Controlled Trial

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Purpose: Currently, it is still undecided if adult patients with displaced extra-articular distal radius fractures should be treated operatively or nonoperatively. The purpose of this randomized controlled trial was to compare the functional outcome of open reduction and volar plate fixation versus plaster immobilization in displaced extra-articular distal radius fractures.

Methods: We performed a multicenter randomized controlled trial in which patients from 18 to 75 years with an acceptable reduced extra-articular distal radius fracture were randomly assigned to open reduction and volar plate fixation or plaster immobilization. The primary outcome was the functional outcome measured with the Disability of the Arm, Shoulder and Hand (DASH) questionnaire after 12 months.

Results: A total of 90 patients were randomized, 47 patients to open reduction and volar plate fixation and 43 patients to plaster immobilization. Median DASH scores were significantly better in the operative group at 6 weeks (22.5 [95% confidence interval (CI) 14.2-35.8] vs 48.3 [95% CI 35.6-57.7], P <0.001), 3 months (6.7 [95% CI 2.5-18.3] vs 27.5 [95% CI 10.0-38.3], P <0.001), 6 months (5.8 [95% CI 0.0-17.5] vs 14.2 [95% CI 7.9-29.6], P = 0.004), and 12 months (2.5 [95% CI 0.0-12.7] vs 9.2 [95% CI 1.7-17.7], P = 0.018). 18 patients in the nonoperative group had fracture displacement or a symptomatic malunion and needed subsequent surgery.

Conclusion: Patients with an acceptable reduced extra-articular distal radius fracture treated with open reduction and volar plate fixation have better functional outcomes after 12 months compared to nonoperatively treated patients. Additionally, 42% of the nonoperatively treated patients required subsequent surgery.

See pages 401 - 442 for financial disclosure information.

The Efficacy of Mini C-Arm Fluoroscopy for the Closed Reduction of Distal Radius Fractures in Adults: A Randomized Controlled Trial

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Purpose: Most distal radius (DR) fractures are initially managed with closed reduction and application of a splint. Mini C-arm fluoroscopy for the closed reduction of pediatric forearm fractures has been shown to produce more accurate reductions with fewer reduction attempts when compared to conventional methods. No study to date has investigated mini C-arm fluoroscopy for the reduction of DR fractures in adults; furthermore, no randomized, controlled trials have been performed for any population. Our null hypothesis is that there will be no difference in the reduction quality of DR fractures in the emergency department (ED) when using mini C-arm fluoroscopy compared to standard reduction techniques.

Methods: This is a prospective, randomized controlled trial evaluating the efficacy of mini C-arm fluoroscopy for the closed reduction of DR fractures in the ED of a single academic Level I trauma center. 60 consecutive adult patients with closed DR fractures requiring reduction between April 2015 and January 2017 were randomized to standard versus fluoroscopically aided reductions. Patients with ipsilateral upper extremity fractures were excluded. All reductions were performed by orthopaedic residents implementing a standardized protocol. The primary outcome measurement was reduction quality (radial height, radial inclination, ulnar variance, and volar tilt) as measured on postreduction radiographs.

Results: Standard reductions were performed in 32 patients, and fluoroscopically aided reductions were performed in 28 patients. There were no statistically significant differences between groups in regards to age, gender, body mass index, mechanism of injury, fracture laterality, AO/OTA fracture classification, presence of an ulnar styloid fracture, or initial fracture displacement. No statistically significant differences were noted between groups on postreduction radiographs with regard to radial height, radial inclination, ulnar variance, or volar tilt. Overall reduction attempts were increased when using fluoroscopy (2.4 vs 1.8, $P = 0.03$), although the number of splints applied was not significantly different. The rate of operative management did not differ between groups.

Conclusion: Fluoroscopy exposes both the patient and practitioner to unnecessary radiation without enhancing reduction quality; therefore, mini C-arm fluoroscopy appears unnecessary for the initial closed reduction of adult DR fractures.

Δ Vehicle Steering Errors and Reaction Time Following Distal Radius Fracture Surgical Fixation

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Purpose: The purpose of this study was to investigate the effects of an acute upper extremity injury on patients' steering ability (reaction time and steering accuracy) following distal radius fracture surgery.

Methods: 23 patients with at least 1 year of driving experience and an acute distal radius fracture treated with open reduction and volar locked plating were prospectively recruited. Steering accuracy and reaction time were tested in a high-fidelity driving simulator based on a production automatic transmission automobile at 3 time points, acute (<14 days), subacute (4-6 weeks), and final (3-4 months) after surgery. Steering accuracy was measured in number of errors, error time and magnitude. Reaction time was measured in seconds. The estimated marginal means and the 95% confidence interval (CI) were calculated. Repeated measures analysis of variance (rANOVA) was used to compare time points. P <0.05 was considered significant.

Results: 21 patients completed the study. Two patients had incomplete data and were excluded, 1 was lost to follow-up, and 1 chose to discontinue due to baseline neuropathic pain. The mean age was 55 years (range, 18-83). 76% were female, and 57% of the injuries were to the dominant hand. All included fractures were classified per the AO/OTA as 23-A2 (2), 23-A3 (3), 23-C1 (7), 23-C2 (5), and 23-C3 (4) fractures. Mean steering reaction times were: acute 0.65 (CI 0.61-0.69), subacute 0.61 (CI 0.53-0.69), and final 0.60 (CI 0.57-0.64) seconds, which was not statistically significant (P = 0.11). Mean number of steering errors were: acute 7.9 (CI 5.1-10.8), subacute 5.0 (CI 3.1-7.0), and final 4.3 (CI 2.7-5.9), which were significantly different (P = 0.002). Mean steering error magnitude and error time were not significant. Average Disabilities of the Arm, Shoulder and Hand (DASH) score by final follow-up was 14, showing that at 3 months the overall upper extremity disability had normalized compared to published distal radius fracture outcomes.

Conclusion: In simulated steering of an automobile, patients had a higher number of steering errors acutely following distal radius fracture fixation; however, this improved significantly over time with the largest improvement between 2 and 6 weeks. While driving ability is complex and multifaceted and the threshold of errors that correlates with safe driving is unknown, the results of this study allow a surgeon to better counsel a patient following surgery.

Δ OTA Grant

See pages 401 - 442 for financial disclosure information.

Effectiveness of Postoperative Analgesic Immobilization in Patients with Distal Radius Fracture Treated with Volar Locking Plating: A Prospective, Randomized Clinical Trial

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Purpose: Volar locked plating has been the gold standard treatment for intra-articular distal radius fractures. The need for postoperative immobilization after this type of fixation is controversial, with some authors advocating its use for analgesia. The objective of this study was to compare the level of pain and function of patients undergoing surgical fixation of distal radius fractures using or not using postoperative immobilization. We hypothesized that there would be no difference between the treatment groups.

Methods: 39 patients with intra-articular distal radius fracture scheduled to receive volar plate fixation were randomly assigned to receive a volar forearm splint immediately after the surgery until 2 weeks postoperatively or conventional bandage. The primary outcome was the level of pain by the visual analog scale (VAS) at multiple assessments from 12 hours to 2 weeks postoperatively. Secondary outcomes included pain scores at 6 weeks, 3 and 6 months, the need for tramadol use, the Disabilities of the Arm, Shoulder and Hand (DASH) score, wrist range of motion, and complications.

Results: 36 patients completed the follow-up. During hospital stay, the mean VAS reached its maximum level at 18 hours postoperatively, with a mean of 4.5 in the No-splint group, and 4.1 in the Splint group, with no significant difference (P = 0.678). After hospital discharge, the maximum pain occurred on the second postoperative day (No splint = 4.0, Splint = 4.3; P = 0.767), and showed a progressive decline until 2 weeks (No splint = 2.4, Splint = 2.1; P = 0.820), with no significant difference in assessments within and after this interval. There was no significant difference in tramadol use during hospital stay (P = 0.296) or at later assessments. The DASH score was similar between the groups at 6 weeks (No splint = 32.6, Splint = 36.5; P = 0.375), and at 3 and 6 months. Wrist flexion-extension and rotation arcs were similar between the groups. One patient in the No-splint group presented with loss of fracture reduction and underwent reoperation. There were no other relevant complications.

Conclusion: Patients with intra-articular distal radius fractures treated with volar locking plating do not benefit from postoperative immobilization in terms of pain control or lower analgesics use. Early and midterm functional scores, wrist range of motion, and complications are similar among patients using or not using immobilization for 2 weeks postoperatively.

A Prospective Randomized Controlled Trial Comparing Open Reduction and Internal Fixation, Non-Spanning External Fixation, and Closed Reduction with Percutaneous Fixation for Dorsally Displaced Distal Radius Fractures

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Purpose: Displaced distal radius fractures that have failed nonoperative treatment with casting have traditionally been managed with additional fixation using either percutaneous pin fixation, internal fixation, or external fixation. However, the introduction of volar locking plates has resulted in increasing trends in the use of internal fixation and more aggressive fracture fixation without strong evidence to support their superiority over other, less costly, surgical procedures. The primary objective of our study was to compare the functional outcomes of patients with dorsally displaced distal radius fractures treated with (1) closed reduction and percutaneous pinning (CRPP), (2) non-spanning external fixation (NSEF), or (3) open reduction and internal fixation with volar locking plate (ORIF).

Methods: We performed a multicenter randomized controlled trial comparing 3 different surgical procedures in adult patients 18 years and older with dorsally displaced extra-articular and simple intra-articular (<2 mm articular displacement) distal radius fractures that failed closed treatment with casting. The primary outcome measures included the Patient-Rated Wrist Evaluation (PRWE), the Disabilities of the Arm, Shoulder and Hand (DASH) score, and the Short Musculoskeletal Functional Assessment (SMFA). Secondary outcome measures consisted of range of motion (ROM), grip strength, and postoperative complications. Patients were evaluated at 6 weeks and 3, 6, and 12 months.

Results: A total of 201 patients were randomized to either CRPP (n = 66), NSEF (n = 63), or ORIF (n = 72) from 8 different trauma centers. The 3 groups had similar preoperative baseline characteristic. At 1-year follow-up, all 3 groups showed a significant improvement in functional outcome scores although there were no significant differences in any of the primary outcome measures between each group. The secondary outcome measures were also similar between groups at final follow-up.

Conclusion: In adult patients with dorsally displaced distal radius fractures, there was no difference in functional outcome between the 3 surgical interventions at 1-year follow-up. Despite a steady increase in the use of volar locking plates, the choice of fixation for these fractures should be based on cost given the equal effectiveness.

See pages 401 - 442 for financial disclosure information.

Role of the Fibula in Predicting Tibial Nonunions After Intramedullary Nailing

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Purpose: The role of a co-existing fibula fracture in early prediction of tibial nonunion has been poorly studied to this point. Data has suggested that fibula healing may be related to tibia healing, but it has also been hypothesized that an intact, fixed, or healed fibula may reduce compressive loads on the tibia leading to nonunion. The purpose of this study was to examine the relationship between fibula fracture characteristics and healing status on tibial nonunion.

Method: A retrospective analysis was performed on 181 tibia fractures treated with intramedullary nailing from 2006-2013. Baseline data included the presence of an open fracture, compartment syndrome, location of the fibula fracture, relationship of the fibula fracture to the tibia fracture, fibula fracture pattern, and fibula fixation. Tibia and fibula healing was scored with the RUST and RUSf (Radiographic Union Score for Fibula), respectively, for each follow-up radiograph. Statistical analysis was utilized to determine the association of all predictive variables with tibial nonunion, defined as undergoing nonunion repair at any follow-up time point.

Results: The average age was 43.3 years, 46% were open fractures, and 7% were associated with compartment syndrome. Closed fractures were associated with a lower tibial nonunion rate compared to open fractures (10.2% vs 24.1%, p=0.01). At both the 3-month and 6-month time points, higher RUST and RUSf score means were seen in patients that did not develop tibial nonunion. A positive correlation was seen between RUSf and RUST scores at all follow-up time points (r=0.51, p<0.01). Intact fibulae (5.6% vs 17.8%), spiral fibula fractures (9.1% vs 20.0%), proximal fibula fractures vs middle and distal (5.1% vs 23.4% and 20.8), and fibula fractures at a different level from the tibia fracture (9.3% vs 20.8%) trended toward a lower nonunion rate but were not statistically significant (p>0.05). No relationship was seen between fibula fixation and tibial nonunion (17.6% vs 17.4%, p>0.05). Compartment syndrome also exhibited a non-significant trend toward increased tibial nonunion (33.3% vs 15.4%, p=0.11).

Conclusion: Increased fibula healing was associated with higher RUST scores and lower rates of tibial nonunion. Although not statistically significant, the observed trend toward lower tibial nonunion rates for intact fibulae, spiral fibula fractures, proximal fibula fractures, and fibula fractures at a different level from the tibia fracture may warrant additional investigation.

Table 1: Means of RUST and RUSf at 3 and 6 months, with p values of associated rank sum testing

	Tibia Nonunion	Tibia Union	p-value (Mann-Whitney U)
3-Months			
RUST	5.9	6.9	0.04
RUSf	6.1	6.9	0.04
6-Months			
RUST	6.4	9.0	<0.01
RUSf	7.9	9.1	0.17

Incidence of Rotational Malalignment After Intramedullary Nailing of Tibial Shaft Fractures: Efficacy of Low-Dose Protocolled Bilateral Postoperative CT Assessment,

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Purpose: Intramedullary (IM) nailing is the treatment of choice in the vast majority of tibial shaft fractures due to minimal surgical approach, superior fracture healing, and rapid functional recovery. However, a major pitfall may be rotational malalignment. The aim of this prospective cohort study was to determine the incidence of rotational malalignment and to evaluate the efficacy of protocolled bilateral postoperative CT assessment of rotational tibial alignment. Our hypothesis is that protocolled CT rotational measurements after tibia nailing are an effective way to diagnose rotational malalignment allowing for early correction.

Methods: Between 2009 and 2016 we prospectively included 156 patients (112 male [72%], 44 female [28%], mean age 41 years) with a unilateral tibial shaft fracture. As per hospital protocol, patients underwent routine low-dose bilateral postoperative CT to assess rotational malalignment. 46 (29%) were compound fractures and in 33 patients (21%) the fracture was part of multitrauma. According to AO/OTA classification, there were 106 simple (68%), 29 wedge (19%) and 21 complex fractures (14%). Seven were proximal third tibial fractures (4%), 103 fractures in middle-third shaft (66%), and 46 fractures (29%) in the distal third tibia. Rotational malalignment was defined as a rotation greater than 10° as compared to the uninjured side.

Results: 56 patients (36%) had postreduction rotational malalignment of 10º or more, including 8 patients (5%) with a rotational malalignment ≥ 20º and 2 patients (1%) with a malrotation ≥ 30° as compared to the uninjured side. Of the patients with rotational malalignment, the tibia was externally malrotated in 29 patients (52%) and internally malrotated in 27 patients (48%). Three patients (2%) underwent revision surgery to correct the malrotation as detected on CT scan.

Conclusion: This study reveals a high incidence of rotational malalignment following tibia nails (36%), with a surprisingly low revision rate (2%). A subsequent study should aim to assess clinical relevance of rotational malalignment in terms of functional outcome and gait analysis. For now CT rotational provides a platform for early recognition and correction of malrotation secondary to tibial IM nailing.

See pages 401 - 442 for financial disclosure information.

Suprapatellar Versus Infrapatellar Approach to Intramedullary Nailing of Tibia Fractures: An Objective Measure of Knee Cartilage

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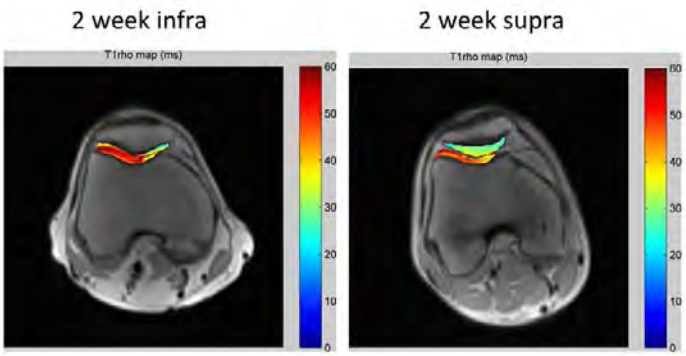
Purpose: Intramedullary nailing (IMN) is the gold standard in surgical stabilization of tibial shaft fractures. Recent literature has sought to evaluate the effect of the suprapatellar approach on the cartilage of the knee. Advances have emerged to objectively quantify the health of the articular cartilage. Utilizing T1ϱ imaging, this study seeks to determine the effects on cartilage health in fracture repair.

Method: All patients with tibia fractures that met inclusion criteria and consented underwent IMN with the approach being randomized. Subjects returned for knee MRI scans at 2 weeks and 6 months post surgery. 8 slices of T1ϱ data were acquired in both the coronal and axial planes. Data were processed using a voxel-by-voxel monoexponential fit algorithm in a custom-written script. Cartilage regions of interest (ROIs) were manually segmented based on raw T1ϱ images. Data were reported as T1ϱ values averaged by ROI and by slice, and the data were then evaluated statistically by utilizing heteroscedastic 2-tailed Student t tests.

Results: 29 tibia shaft fracture subjects with an average age of 32.5 years were recruited and consented. Of the 29, 9 subjects who were randomized to the suprapatellar approach underwent 2-week scans, 7 subjects who were randomized to the infrapatellar approach underwent 2-week scans, and 15 of these 16 subjects had contralateral knee T1ϱ MRI scans. For the 6-month T1ϱ MRI scans, there were 2 from the suprapatellar group, 2 from the infrapatellar group, and 4 with bilateral scans. At 2 weeks, data from the patellofemoral compartment indicate slightly increased average T1ϱ values in subjects having undergone the infra-patellar procedure relative to the supra-patellar procedure. These differences were not statistically significant. T1ϱ data from tibial and femoral trochlear cartilage ROIs show an insignificant degree of difference. For all ROIs evaluated at 2 weeks post surgery, the subjects' contralateral knees exhibited high T1ϱ values. At 6 months, most cartilage ROIs show a general reduction in average T1ϱ values, as expected due to subject recovery.

Conclusion: The suprapatellar and infra-patellar approaches to IMN insertion into the tibia have nearly indistinguishable effects on T1ϱ values in the patellofemoral joint. The T1ϱ values reveal little impact on the cartilage of the involved knee in suprapatellar nailing compared to infrapatellar, suggesting suprapatellar nailing is a safe alternative.



Is Continuous Near-Infrared Spectroscopy (NIRS) Reliable to Monitor Development of Compartment Syndrome in Patients with Lower Leg Injuries?

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Purpose: Tissue oximetry using near-infrared spectroscopy (NIRS) is a potential diagnostic tool for acute compartment syndrome (ACS). We obtained continuous NIRS and intramuscular pressure (IMP) data in a study to develop models for predicting ACS in lower leg injuries. We report our experience with NIRS and explore factors affecting data capture.

Methods: 191 patients were enrolled in an IRB-approved trial. Patients had continuous IMP recording in the anterior and deep posterior compartment of the leg, and continuous NIRS measurement in the anterior compartment of the injured and a control limb. Data were recorded for a prescribed time period starting at enrollment. For IMP and NIRS, the percent of valid data was defined as the ratio of observed data points within a valid physiological range to the total number of expected data points. Clinically useful NIRS data required simultaneous data from injured and control legs to calculate the ratio of the two. Paired Wilcoxon signed rank test was used to compare the two methods. A multiple beta-regression model was used to explore factors affecting NIRS data capture.

Results: Clinically useful NIRS data were available 9.1% of the expected time. In contrast, clinically useful IMP data were observed 87.6% of the expected time ($P < 0.001$). Excluding 46 patients who had no NIRS data at all, these percentages were 31.6% for NIRS versus 87.4% for IMP data ($P < 0.00001$). Fractures with an associated hematoma were less likely to have valid data points (odds ratio [OR] = 0.53, $P = 0.04$). Gustilo open fracture types I and II were more likely than Tscherne closed fracture type 0-I to have valid data points (OR = 1.97, $P = 0.03$). No factors were significantly associated with variation in NIRS data capture in the control limb.

Conclusion: In this study, NIRS data were not collected reliably. Assessment of muscle perfusion using NIRS depends on the ratio of oxygen saturation in the injured limb to a control limb. Useful NIRS data were collected less than 10% of the expected time in our overall group, and less than a third of the time in the subgroup of patients that had at least some NIRS data recorded. In contrast, IMP measurements were collected in over 85% of the expected monitoring period. Clinicians responsible for treating ACS should be aware of these limitations when choosing how to monitor their patients. Furthermore, it appears that NIRS monitoring may not be sufficiently reliable in developing models for diagnosing ACS.

See pages 401 - 442 for financial disclosure information.

Does Early Administration of Antibiotics After Open Tibia Fractures Really Decrease Infection Rates?

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Purpose: A recent report has indicated that patients who received antibiotics within 66 minutes of injury were at decreased risk for surgical site infection. Our goal was to confirm this finding and evaluate the effect of time from injury to prophylactic antibiotic delivery and other potentially modifiable treatment parameters on deep infection with open tibia fractures. Our hypothesis is that earlier delivery of antibiotics would be associated with lower infection rates.

Methods: Our IRB-approved study was a retrospective prognostic study performed at an urban Level I trauma center. The study group was 289 patients with Gustilo-Anderson type I-III open tibia fractures with at least 3 months follow-up. The primary outcome measure was deep surgical site infection treated with surgical debridement. 58 patients (20%) developed a deep infection. The infected (n = 58) and uninfected (n = 231) patients were comparable with regard to injury severity, comorbidities, age, ISS, tobacco use, diabetes mellitus, body mass index, and cefazolin as primary antibiotic (P ≥0.10).

Results: Univariate and multivariate analysis of time to antibiotic administration within 66 minutes was associated with increased infection risk (25% vs 15%, P = 0.04) but those patients arriving within 66 minutes were more likely to have type IIIB/C fractures (26% vs 14%, P = 0.01). Further subgroup analysis excluding type IIIB/C fractures found no statistically significant association of antibiotic timing and infection (P = 0.10). Multivariate analysis demonstrated type IIIB/C fractures (P = 0.003) and patients with delayed arrival to the definitive trauma center >6 hours (P = 0.02) was predictive of increased risk of deep surgical site infection.

Conclusion: In contrast to a recent publication and perhaps developing dogma, we did not find that early antibiotic administration decreased the risk of infection in patients with open tibia fractures. The reason for the differences between our findings and those of the previous authors are unclear, but there are several other reports confirming our findings. Clinicians and emergency medical services providers should be aware that that there is some controversy regarding the likely efficacy of moving antibiotic delivery into the prehospital setting as has been proposed. Further, even with urgent patient resuscitation, early antibiotic administration, timely flap coverage when needed, and urgent surgical debridement, infections still occur at a relatively high rate for type I-III open tibia fractures.

Best Trauma Paper at the 2017 POSNA Annual Meeting
"Acceptable Reduction" for Supracondylar Humerus Fractures in Children

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Purpose: Following reduction and percutaneous fixation of humeral supracondylar fractures what is the magnitude of allowable intra-operative residual displacement compatible with a good clinical outcome?

Methods: 221 children, mean (SD) age 6.2 yrs (2.3), who underwent closed reduction and percutaneous wire fixation of supracondylar humerus fractures were prospectively enrolled at a tertiary pediatric hospital over a 18 month period. Intra-operative AP and lateral radiographs were analyzed to determine residual displacement after fixation. At 3 months, patient/parent reported outcomes were measured using the Quick DASH (0 best to 100 worst), the PROOF (0 best to 16 worst), in addition to elbow range of motion and standardized photographs of both upper limbs to record and compare carrying angles.

Results: Range of residual displacement was from 4.5 mm (15%) lateral to 7.0 mm (30%) medial; 6 mm (37%) posterior to 6 mm (33%) anterior. Baumann's angle ranged from 59° to 83° (Ave 70°). The anterior humeral line crossed at or behind the anterior 1/3 of the capitellum in 219/221 patients. At 3 months, 211 out of 221 patients (95%) had a good functional outcome. The mean (SD) Quick DASH score was 2.06 (6.9). The mean (SD) PROOF score was 0.93 (1.57). There was little correlation between the amount of fracture displacement in any plane and the QuickDASH score; or PROOF-UE; carrying angle or range of motion.

Conclusion: In this prospective cohort of children with supracondylar humerus fractures treated by closed reduction and percutaneous wiring fixation, up to a displacement of 30% medial to 15% lateral in the AP plane and 33% anterior to 37% posterior in the sagittal plane, a Baumann's angle between 59 and 83 degrees and an anterior humeral line that does not cross anterior to the capitellum is completely compatible with an excellent outcome based on physical appearance (carrying angle), range of motion, function and patient reported outcomes. Within the parameters described, the surgeon does not need to revise or improve upon the reduction of a SCH fracture treated with closed reduction and pinning to obtain an excellent clinical outcome. If replicated in a larger cohort, this might result in fewer open reductions, and less time to achieve a satisfactory closed reduction.

See pages 401 - 442 for financial disclosure information.

Single Versus Both Bone Fixation: A Retrospective Review of 10 Years of Pediatric Forearm Fractures

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Purpose: Traditionally, operative management of pediatric forearm fractures consists of fixation of both the radius and ulna, although single bone fixation may be a viable alternative. This study compares the treatment outcomes of single versus both bone fixation of surgical pediatric forearm fractures.

Methods: This is a retrospective study investigating patients under the age of 18 years undergoing operative fixation of all 21-M, 22-D, and 23-M both bone forearm fractures between 2003 and 2013 at a single institution. The decision to use single bone fixation was physician preference based on intraoperative stability following fixation of the first bone. Charts were reviewed for clinical and radiographic data through multiple time intervals. Comparative analysis of time to union, loss of reduction, tourniquet time, and overall cost of treatment were examined across each fixation type and zone of injury. Complication rates (including need for revision surgery, neurovascular injury, malunion, nonunion, and symptomatic hardware) were also investigated.

Results: A total of 369 patients met inclusion criteria: 302 patients (82%) received fixation of both radius and ulna fractures while 67 (18%) received fixation of only the radius or ulna. There was no significant difference between gender and proportion of open injury, single bone fixation groups were younger (8.8 vs 11.4 years; $P < 0.001$) and were more often treated with distal (23-M) fracture patterns (40 vs 19%; $P < 0.001$). There was no significant difference in the number of patients that achieved union by 210 days between both bone and single bone fixation groups (87 vs 82%; $P = 0.370$). Patients undergoing single bone fixation had a shorter time to radiographic union (132 vs 153 days; $P = 0.014$) and shorter operative time (65 vs 96 minutes; $P < 0.001$). Reduction was stable across all fixation types and time periods with the exception of early loss of reduction of 5° in the radius for ulna-only fixation ($P = 0.002$). Hospital encounter costs were lower for single bone fixation ($11,400 vs $18,500; $P < 0.001$). The complication rate was not significantly different for single bone fixation (27% vs 20%; $P = 0.204$).

Conclusion: The use of single bone fixation of pediatric both bone forearm fractures remains controversial. This study demonstrates that single bone fixation may have a shorter time to union, shorter operative time, and less overall cost, without compromising stability or increasing complication rate.

The Utility of Intraoperative Arthrogram in the Management of Pediatric Lateral Condyle Fractures of the Humerus

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Purpose: Arthrograms are commonly used to assess articular reduction in conjunction with closed reduction and percutaneous pinning (CRPP) of pediatric lateral condyle fractures of the humerus, but there is no clear consensus on the indications for arthrogram use. The purpose of this study is to determine how intraoperative arthrogram affects the management of pediatric lateral condyle fractures.

Methods: An IRB-approved retrospective chart review of all lateral condyle fractures treated at an academic urban pediatric Level I trauma center from 2008-2014 was performed. Injury parameters, initial fracture displacement, and complications were compared between fractures managed with and without an arthrogram as well as between those that had an arthrogram prior to fixation and those in which the arthrogram was performed following reduction and fixation.

Results: 875 patients with lateral condyle fractures were identified of which 107 patients underwent intended CRPP. 58 patients were treated with CRPP without arthrogram, and 49 with arthrogram. Of those who had an arthrogram, 22 (45%) were performed after fixation and 27 (55%) before definitive fixation. Management was changed in 4 patients (14.7%) who had arthrograms prior to fixation versus no patients who had arthrograms after definitive fixation ($P = 0.060$). Of those in whom the arthrogram altered the surgical plan, 3 patients were converted to open treatment and one was converted to cast without pins. Mean preoperative displacement was similar in patients treated with and without arthrograms (3.04 mm vs 2.91 mm, $P = 0.836$); however, mean postoperative displacement was lower in patients without arthrograms (0.91 vs 1.68 mm, $P < 0.001$). There were no significant differences in age, weight, energy mechanisms of injury, or complication rates between either of the groups.

Conclusion: Utilizing an arthrogram before CRPP resulted in a treatment change in a small percentage of patients while no patient who had an arthrogram after CRPP had a change in management. Mean postoperative displacement was lower in patients without arthrograms. Use of an arthrogram following CRPP of lateral condyle fracture may be useful to assess final fracture alignment but is unlikely to result in a treatment change and was not associated with improved postoperative alignment.

See pages 401 - 442 for financial disclosure information.

Is Less More? Assessing the Value of Early Clinical and Radiographic Follow-up for Operative Supracondylar Humerus Fractures

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Purpose: Postoperative protocols following surgical management of pediatric supracondylar humerus (SCH) fractures are variable and often based on surgeon preference. The purpose of this study was to determine the value of early clinical and radiographic follow-up.

Methods: A retrospective review of prospectively collected consecutive patient data treated for SCH fractures with closed reduction and percutaneous pinning (CRPP) between 2009 and 2014 at a single center was conducted. Unanticipated interventions and previously undiagnosed neuropathies documented at the 1-week postoperative visit were identified. Comparisons of unscheduled visits and complications were made between patients with an initial follow-up visit at 1 week postoperatively (early group) and those first seen at an average 3 weeks postoperatively (late group). Statistical analysis was completed using independent samples t test, nonparametric Mann-Whitney U, chi-square, and Fisher's exact tests.

Results: Of 873 patients, 823 (94.3%) were seen early, and 50 (5.7%) were seen late. In the early group, 8 of 823 (1%) had a change in management secondary to clinical findings, and 12 of 823 (1.5%) were noted to have a previously undocumented neuropathy. 754 of 823 (91.6%) had radiographs at the 1-week visit, which resulted in a change in management in 1 patient (0.1%). There was no difference in unscheduled visits (2.9% vs 4%, $P = 0.66$) or in complications identified after 1 week (1.6% vs 0%, $P > 0.99$) between the early and late group. Radiographic parameters were comparable at final follow-up (Bauman's angle 74.5° vs 73.7°, $P = 0.40$; lateral humeral condylar angle 40.2° vs 41.2°, $P = 0.53$). Further, altering immobilization at the 1-week visit was not protective against unscheduled visits ($P = 0.37$) or complications ($P = 0.48$). At final follow-up all patients, independent of postoperative protocol or early alteration in management, went on to radiographic union without functional limitation.

Conclusion: The 1-week postoperative visit following SCH fracture CRPP rarely leads to alterations in care and does not reduce unscheduled visits or late complications. The findings of this study allow treating physicians to safely avoid radiographic examination and alterations to external immobilization at 1 week postoperatively, effectively reducing cost and time spent in the management of SCH fractures.

Incidence of Complications and Mortality in Polytrauma Patients Managed Either with ETC or DCO: Lessons Learned

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Purpose: We hypothesize that polytrauma patients treated with Early Total Care (ETC) had a lower mortality rate and incidence of complications compared to the group of patients managed with Damage Control Orthopaedics (DCO).

Methods: 1695 polytrauma patients with ISS ≥16 were eligible to participate. Inclusion criteria were patients who had suffered a long bone shaft fracture that was managed either with external fixator (DCO) or intramedullary (IM) nailing (ETC). Data analyzed included initial physiological state (blood pressure, pulse rate, lactate, acid base balance, coagulation parameters), ISS, blood transfusion requirements, AIS (Abbreviated Injury Scale) per body region, mechanism of accident, operations performed, ICU stay, length of hospital stay, complications, and mortality. Descriptive statistics were performed as appropriate for comparison among the 2 groups.

Results: 360 patients met the inclusion criteria (205 patients managed with DCO and 155 with ETC). Mean age was 44.64 years (range, 16-95), mean ISS was 27.3 points (range, 16-66) and mean Glasgow Coma Scale (GCS) was 14 on arrival. In the DCO group the mean ISS = 27.65, GCS = 14.02, and time to operation was 12.89 hours. 43 patients required blood products with an average of 4.30 units per patient. Average ICU stay was 4.73 (SD = 8.87) days; average hospital stay was 21.54 (SD = 21.17) days. 37 patients experienced complications. There were 5 deaths. The percentage of regional anatomical injuries with their AIS was: head 38.50% (3.3), chest 65% (3.25), abdomen 26% (2.54), pelvis 62.5% (3.64), spine 58% (2.37), limbs 81% (2.52). In the ETC group the mean ISS was 26.79, GCS = 13.72, and time to operation was 13.01 hours. 26 patients required blood products with an average of 6.92 units per patient. Average ICU stay was 3.41 (SD = 6.6) days and average hospital stay was 15.4 (SD = 16.86) days. 17 patients experienced complications. There were a total of 7 deaths. The percentage of regional anatomical injuries with their AIS was head 38.71% (2.98), chest 65.81% (3.39), abdomen 24.52% (2.76), pelvis 42.58% (3.61), spine 50.32% (2.55), limbs 78.06% (2.57). Comparison of no survivors for the ETC and DCO group of patients revealed the following: nonsurvivors ETC 7 of 155 (4.52%), DCO 5 of 205 (2.44%); age 63.79 versus 76.12 years; shock 71.43% versus 40%; ISS 37.71 versus 30.2; head injury 42.86% versus 60%; chest injury 85.71% versus 20%; abdomen injury 42.86% versus 20%; pelvis injury 71.43% versus 40%; spine injury 42.86% versus 60%; limb injury 71.43% versus 60%; and death post admission 14 days versus 10.4 days.

Conclusion: Both strategies were found to be effective but ETC was associated with almost double mortality rate and should be practised with caution.

See pages 401 - 442 for financial disclosure information.

Extremity Trauma Results in Severe Coagulopathy and Impaired Fibrinolysis Based on Serial Rapid Thrombelastography

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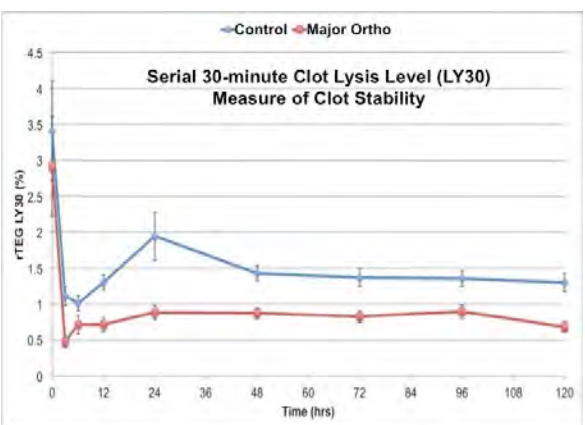
Purpose: Trauma-induced coagulopathy correlates with morbidity and mortality. Rapid thrombelastography (rTEG) evaluates the clotting function of whole blood and is now used to guide blood product resuscitation. Elevated maximal amplitude (MA) has been shown to be predictive of in-hospital venous thromboembolic events (VTE). To date, coagulopathy has not been studied in major extremity trauma beyond 24-hours post-injury.

Method: Subset analysis of a prospective, observational trial evaluating serial rTEG in severely injured patients. Serial rTEG (activated clotting time, k-time, a-angle, MA, lysis) and traditional coagulation testing were obtained at admission and then at 3, 6, 12, 24, 48, 72, 96, and 120 hours. Patients were dichotomized into ORTHO (extremity AIS>2) or CONTROLS (extremity AIS 0-2). Univariate analysis was conducted, followed by longitudinal analysis using generalized estimating equations (GEE) to evaluate the effects of time, splenectomy, and group-time interactions on changes in rTEG, controlling for age, gender, base deficit and ORTHO group. A multiple logistic regression was developed to evaluate the development of VTE.

Results: 340 patients had complete serial rTEG data; 75 were classified as ORTHO and 265 were CONTROLS. There were no differences in baseline demographics or non-extremity AIS scores. ORTHO patients were more likely to have sustained blunt mechanism (91% vs. 62%) and have higher ISS (median 27 vs. 17); both $p<0.001$. ORTHO patients were more unstable on arrival (median Revised Trauma Score 3.51 vs. 6.81, $p=0.035$). Based on the GEE model, the ORTHO group was more hypocoagulable, as measured by k-time and decreased MA, over the first 5-days post-injury. However, despite being unexpectedly more hypocoagulable, the ORTHO patients demonstrated impaired lysis ($p<0.05$) and had an increased VTE rate (13.3% vs. 1.8%; $p<0.001$) compared to CONTROLS. On multivariate analysis, ORTHO was an independent predictor of in-hospital VTE (Odds Ratio = 6.36; 95% CI = 1.94 to 20.81; $p=0.002$).

Conclusion: Based on 5-day serial rTEG analysis of 340 trauma patients, the ORTHO group was more coagulopathic. Both groups became progressively more hypercoagulable, however, ORTHO patients were more hypocoagulable. Despite this, ORTHO patients had decreased fibrinolysis, which may translate into higher VTE. Major extremity trauma remains a strong, independent predictor of VTE.



The Early Immunologic Response in Multiply Injured Patients with Orthopaedic Injuries Is Associated with Organ Dysfunction

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Purpose: Hemodynamic stability, acidosis (pH, base deficit, lactate), and physiologic status guide timing and extent of fracture fixation in multiply injured patients (MIPs). An exaggerated inflammatory response following trauma has been implicated in the development of nosocomial infection (NI) and organ dysfunction. This study sought to correlate the acute immunologic response to short-term complications in MIPs with destabilizing orthopedic injuries.

Method: 61 MIPs, ages 18-55, admitted to the ICU with operative femur, tibia, and all pelvic/acetabular fractures were prospectively evaluated. Blood was collected at 0, 8, 24, and 48 hours post-injury. Serum analyses were performed using a panel bioassay of 20 cytokines. Clinical data including Marshall Multiple Organ Dysfunction (MOD) score and NI were recorded. Cytokine levels were compared in groups of patients with an average MOD score on days 2-5 of ≤3 or >3 and in patients with/without NI.

Results: MODS >3 (n=33) had higher concentrations of IL-6, IL-8, IL-10, and MCP-1 than MODS ≤3 (n=28) (Fig. 1). Patients with NI (n = 24) had elevated levels of MCP-1 and IL-10 compared to patients without NI (n = 37).

Conclusion: Progression of an exaggerated immunologic response 48 hours following injury, evidenced by higher circulating concentrations of IL-6, IL-8, IL-10, and MCP-1 identified patients at risk for MOD and NI. Biomarker patterns may offer important information to titrate both initial and staged fracture surgery.

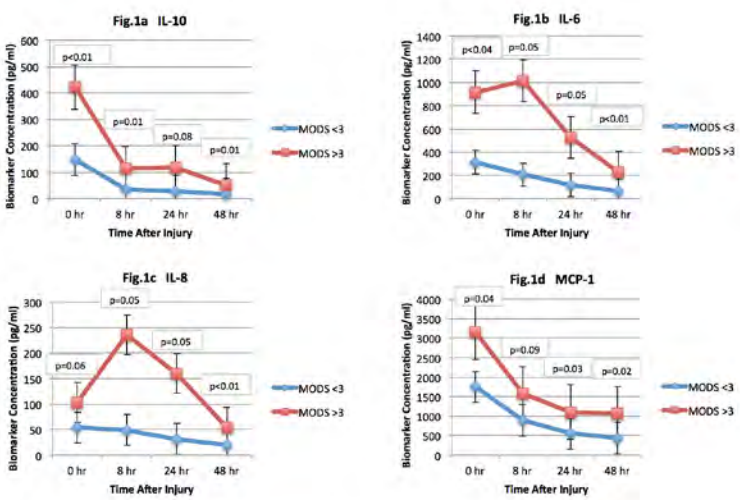

Figure 1 a-d. Multiply Injured Patients with orthopaedic injuries that developed a greater degree of organ dysfunction (MODS >3) demonstrated an exaggerated inflammatory response over the first 48 hours following trauma compared to patients with less organ dysfunction (MODS ≤3).

See pages 401 - 442 for financial disclosure information.

Significant Reduction of Pulmonary Embolism in Orthopaedic Trauma Patients

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Purpose: This is a report of results of a protocol intended to lessen incidence of pulmonary embolism (PE) among orthopaedic trauma patients. The protocol centered on rapid identification of high-risk patients, higher enoxaparin dosing, and use of inferior vena cava filters (IVCFs) in those patients. We did a retrospective review of the number of PEs seen in orthopaedic trauma inpatients from September to December 2016, when our protocol was in place, and compared it to the number from September to December 2015.

Methods: Based on our previous PE risk algorithm, we developed a protocol to prevent PE in high-risk patients. Risk calculation includes age, injury mechanism, method of transport to the ER, heart rate on arrival, obesity, presence of injury to the thorax, abdomen, or lower extremities, pelvis, or acetabulum, and planned admission to the surgical ICU. If possible, high-risk patients are given their first dose of enoxaparin in the ER. 40 mg BID is used for patients >50 kg and 30 mg if 0.5 IU/mL, the dose is reduced.

Results: From September 1 through December 31, 2015, our hospital admitted 420 orthopaedic trauma patients. 51 were classed as high risk for PE. In September through December 2015, 9 sustained PE, 1 of which was fatal. From September 1 through December 31, 2016, our hospital admitted 368 orthopaedic trauma patients with comparable age and ISS to 2015. 40 were at high risk for PE, 1 sustained a nonfatal PE. PE incidence from September through December 2016 was significantly lower than in 2015 ($P = 0.02$). Overall, 23 patients managed under the new protocol had IVCFs placed. 15 had their filters removed. 3 died with filters in place. The remaining have follow-up with interventional radiology for removal. There were no complications during filter placement or removal. 2 IVCFs were found to have clot beneath them which prevented filter removal. 1 patient had hemorrhage felt to be attributable to enoxaparin.

Conclusion: We aimed to identify those patients at highest risk for PE. Our protocol emphasizes more robust enoxaparin dosing, and more frequent use of IVCF, but only among those at highest risk. Our protocol was successful at lessening the incidence of PE, with a low complication rate. We expect that our results can be replicated at other centers.

Limitations in Upper-Extremity Weight-Bearing Increase Length of Stay in Polytraumatized Patients

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Purpose: There are little objective data available to guide weight-bearing restrictions in polytrauma. However, these restrictions have the potential to have a profound effect on patients' ability to regain functional independence. The purpose of this study was to identify whether upper-extremity weight-bearing in patients with combined upper- and lower-extremity injuries affects hospital length of stay (LOS), disposition status, and/or independence with physical therapy at time of discharge.

Methods: The study included 371 patients with combined upper- and lower-extremity fractures from 2006 to 2015. Patients were included if they were ≥16 years who sustained combined upper- and lower-extremity fractures. The primary outcomes were hospital LOS and disposition status. A secondary outcome measure was time to mobilization with physical therapy during hospital admission, documented as ability to stand-pivot-transfer with physical therapy. Method of treatment and postoperative weight-bearing status were at the discretion of the attending surgeon.

Results: Univariate analysis demonstrated that mean hospital LOS was significantly longer for patients whose weight-bearing was restricted in either upper extremity than those who were bearing weight with bilateral upper extremities (15.2 days vs 10.3 days, $P < 0.001$). A significant difference was shown in disposition (12% to home in those with weight bearing vs 6%, $P < 0.001$) and independence with physical therapy (28% required maximum assist or were completely dependent in those with weightbearing vs 40%, $P < 0.001$) between the 2 groups. Linear regression analysis showed that upper-extremity weight bearing was an independent predictor for decreased hospital LOS and was associated with a 23% decrease in hospital LOS when adjusted for confounders.

Conclusion: Permitting polytrauma patients with combined upper- and lower-extremity injuries to bear weight in bilateral upper extremities is associated with a decrease in hospital LOS, improved disposition status and increased independence with physical therapy at time of discharge (all $P < 0.001$). Allowing upper extremity weight bearing has the potential to encourage mobility after polytrauma, which may even result in quicker return to independence, and perhaps also contribute to cost reductions.

See pages 401 - 442 for financial disclosure information.

Extra-Articular Malunions and Nonunions of the Scapula:
A Comparison of Functional Outcome Before and After Reconstruction

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Purpose: This study includes the largest cohort of operatively treated scapula malunion and non-union reconstruction, and aims to assess surgical and functional results.

Methods: This is a review of 26 patients-16 malunions in 15 patients & 18 nonunions in 14 patients. Intervention involved surgical osteotomy of the malunion or debridement of the nonunion and ORIF. Outcome measures included: pre/post-op ROM, strength and DASH scores, and return to work.

Results: Among 21 of 26 (81%) patients with ³12 months follow-up, mean=36 months. 5 patients were lost to follow-up and excluded. Mean age=48.5 years. Average time from injury to surgery=22.6 months. Preoperative ROM and strength were obtained on 18/26 (69%). Mean DASH score improved from 55 preoperatively to 18 postoperatively ($p<0.001$). Among the patients with ³1 year follow-up, range of motion improved from pre-operative to final follow-up in forward flexion and abduction ($p= 0.002$ and $p= 0.001$ respectively). Range of motion for ER and all strength measures improved but did not reach significance. Among the 20 of 26 patients for whom occupation data is available, 80% either returned to their original occupation (n = 10) or did not due to reasons other than their reconstructive surgery (n = 6). Two post-operative complications occurred: acromion stress fracture and hardware failure (3 months postoperatively). Both patients went on to heal after revision surgery. All reconstructions subsequently united without malunion.

Conclusion: Scapula reconstruction of malunion and non-union is possible and associated with an acceptable complication rate, restoration of function, and symptom relief.

Timing of Definitive Fixation with Respect to Flap Coverage in Open Tibia Fractures

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Purpose: In grade 3B and C open tibia shaft fractures, authors have demonstrated that time from injury to coverage correlates with infection. We hypothesized that the time to coverage from the time of definitive fixation is more important in the overall risk of infection. The purpose of this study was to evaluate factors associated with infection in open tibial shaft fractures requiring flap coverage.

Methods: All patients with grade 3B or C open tibia shaft fractures at 14 trauma centers were retrospectively reviewed. We collected demographics, time of initial debridement, definitive fixation and coverage, type of fixation and flap, and complications. We evaluated use of temporary internal fixation, flap failure, and times from initial debridement and definitive fixation to coverage against deep infection as the primary outcome. We used Student t tests, Fisher's exact test, univariate logistic regression, and multivariate regression for data analysis.

Results: Of 296 adults (227 M: 69 F) with open tibial shaft fractures requiring flap coverage, 74 (25%) became infected. Definitive external fixation (36) had a higher incidence of infection ($P = 0.008$). Time from definitive internal fixation to coverage ($P = 0.04$) and flap failure ($P < 0.001$) were associated with infection, but time from injury to coverage ($P = 0.13$) and use of temporary internal fixation ($P = 0.6$) were not. Flap failure correlated strongly with infection ($P < 0.001$) and time from definitive fixation to coverage trended toward significance ($P = 0.09$). Time from injury to coverage ($P = 0.9$) and temporary internal fixation ($P = 0.5$) were not associated with infection.

Conclusion: In this study, definitive external fixation, flap failure, and time from definitive internal fixation to coverage correlated with infection. Time from injury to coverage was not associated with infection. This indicates that time from definitive internal fixation to coverage is more critical than time from injury to coverage and that temporary internal fixation does not increase the risk of infection.

See pages 401 - 442 for financial disclosure information.

Rates of Surgical Site Infection After Open Fractures: Findings of the UK Wound Management of Open Lower Limb Fractures (WOLLF) Trial

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Purpose: Surgical site infection (SSI) remains a common and significant problem after open fracture. Rates of superficial and deep SSI are estimated between 13% and 26%, although rates vary by definition used. Given that deep infection can result in extensive treatment, including further surgery, it is an important and potentially modifiable outcome after open fractures. We sought to test the effect of different means of diagnosis in the context of the trial.

Methods: We investigated the rate of deep SSI within a multicenter randomized controlled clinical trial comparing negative pressure wound therapy (NPWT) to standard usual care in adults with open fractures of the lower limb. We assessed SSI rates using different criteria: (1) the Centers for Disease Control and Prevention (CDC) definition for superficial and deep SSI assessed at 6 weeks after surgery, (2) digital photographic images taken at 6 weeks, and (3) medical or surgical treatment for deep SSI within 12 months of surgery. At 6 weeks, wounds were assessed and photographed by an independent research assistant. Medical records and adverse event reports up to 12 months after initial surgery were reviewed by an independent surgeon.

Results: A total of 460 participants were randomized to trial interventions (NPWT, n = 226; standard care, n = 234). Median age was 42.5 years (interquartile range, 29-61). The CDC definition comprises multiple individual criteria. For superficial SSI, 68 participants (14.8%) had 1 or more wound symptoms present within 6 weeks of surgery (NPWT 15.5% vs standard care 14.1%). 35 (7.5%) had deep SSI (NPWT 7.1% vs standard care 8.1%). 6-week infection based on assessment of photographic images alone was 12.6% (58 of 460). Longer term follow-up using any medical or surgical treatment of infection within 12 months yielded a deep SSI rate of 17.1%. No differences were found by treatment group by any infection definition.

Conclusion: This is the first large-scale clinical trial to accurately capture infection rates over time after surgical repair of open lower limb fracture. Rates vary by definition used and duration of follow-up. Measurement of deep SSI in the acute postoperative period grossly underestimate longer-term rates. Future studies looking to assess interventions that affect infection should make careful assessment of how the diagnosis of infection is made.

Impact of Management on Reoperation Rates in Gustillo-Anderson Grade III Open Fractures of the Lower Limb

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Purpose: The British Orthopaedic Association (BOA) and the British Association of Plastic, Reconstructive and Aesthetic Surgeons (BAPRAS) have produced standards of care for severe lower limb injuries since 1997 and National Institute for Health and Care Excellence (NICE) guidance was released in 2016. These place emphasis on a combined orthoplastic approach to ensure best outcomes for patients. Our aim is to assess the effect of single-stage versus multistage definitive orthoplastic reconstruction on reoperation rates secondary to infection or nonunion.

Method: A retrospective review of patients presenting to a major trauma center in the UK with an open lower limb fracture. All patients with Gustilo-Anderson (G-A) III injuries of the lower limb between April 2013 and March 2015 were included. Exclusion criteria applied were death and incomplete follow-up data.

Results: Eighty-seven patients with 87 fractures were identified. The tibia and fibula were involved in 87% and 56% sustained a G-A IIIb injury. Procedures were classified as single-stage orthopaedic, single-stage orthoplastic, and multistage orthoplastic. Single-stage orthoplastic procedures were performed in 47%. Reoperation due to either deep infection or nonunion was required in 16%. G-A IIIa injuries treated with a single-stage orthopaedic approach were most likely to require reoperation within 1 year (24%). Considering all G-A III injuries, those treated by a single-stage orthoplastic approach had a significantly reduced reoperation rate of 7%, compared to a multistage approach reoperation rate of 30% ($P = 0.028$). Patients who received definitive fracture fixation and soft-tissue cover between 72 hours and 7 days had the lowest reoperation rate, 6.3%. The rate was higher in those waiting less than 72 hours and more than 7 days, 15% and 33%, respectively.

Conclusion: We have found that a single-stage orthoplastic approach to the management of open lower limb fractures affords the best outcome for our patients in terms of reduction in reoperation rates. Traditionally, emphasis has been placed on timing of the procedure; however, we believe that more weight should be placed on combined orthoplastic management of these injuries. There may be an advantage in delaying definitive stabilization and soft-tissue reconstruction beyond 72 hours following the injury. This may be due to the soft tissue declaring itself following the trauma. As management of these injuries evolves, the importance of a combined orthoplastic approach to long-term outcomes is becoming more and more evident.

See pages 401 - 442 for financial disclosure information.

NURD 2.0: Prediction of Tibial Nonunion at Any Time Within 3 Months of Injury

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Purpose: The ability to predict likelihood of nonunion after tibial shaft fracture would be helpful to clinicians and patients. Previous risk models have been developed at discrete time points, but there exists no composite model that can predict nonunion regardless of the time of follow-up within the first 3 months. Our hypothesis is that a score (Nonunion Risk Determination score 2.0 [NURD 2.0]) will have adequate utility for clinical use.

Methods: In order to create a model that encompassed all time points, we combined data from 3 previously presented analyses. These data were based on a cohort of tibial shaft fractures treated with nail at our Level I trauma center from 2007 to 2014. We excluded patients who did not have contact between bone ends, who had planned bone graft procedures for acute bone defects, and those without adequate follow-up. Three models were combined that entailed 382 patients at time 0, 323 patients at 6 weeks, and 240 patients at 12 weeks. The nonunion rate in the entire cohort was 14.7%. We included 42 clinical and radiographic variables that had been previously hypothesized to be associated with nonunion in our analysis. Bivariate and multivariate regression analyses were used to determine variables significantly associated with nonunion. Predictive power was evaluated using the area under the curve (AUC) statistic. AUCs >0.8 suggest that 80% sensitivity/specificity can be achieved, and AUCs >0.9 may meet the threshold of clinical utility.

Results: The original NURD score at time of initial fixation was significantly improved through addition of 6 and 12-week RUST (Radiographic Union Score for Tibial Fractures) scores, infection and complications, smoking status, and the need for flaps. Individually, NURD-based models achieved AUCs of 0.81 at time of initial fixation, 0.87 at 6 weeks, and 0.88 at 12 weeks. Taken as a whole over the course of 12 weeks, the NURD-based model produced an AUC of 0.87 at the initial time of fixation and improved to over 0.9 at 6 and 12 weeks. It was possible to use this approach to bin patients into 5 clinically important risk strata ($P < 0.001$). Patients in the lowest risk strata had 0% probability of nonunion (0 of 62 patients). Patients in the second lowest risk strata had a 3.4% (3 of 87) probability of nonunion. Patients in the 2 highest risk strata had 20.8% (25 of 120) and 53.7% (22 of 41) probabilities of nonunion.

Conclusion: We were able to combine 3 previous models into a new nonunion risk score that can predict nonunion at any time point in the first 3 months. The combination of baseline NURD scores and clinical measures identified during routine follow-up allow surgeons to bin patients into clinically important risk categories. About 40% percent of patients, those in the 2 highest risk categories, have a sufficiently high probability of nonunion to merit increased follow-up and possibly acceleration of intervention protocols. The new model (NURD 2.0) is a significant improvement over prior models that are based on a single time point from surgery. A computerized version of the score will allow surgeons and patients to easily use the score to help make decisions regarding the need for nonunion surgery.

Delay in Flap Coverage for Open Tibia Fractures Increases Inpatient Complications: A Cohort Study of 140 North American Trauma Centers

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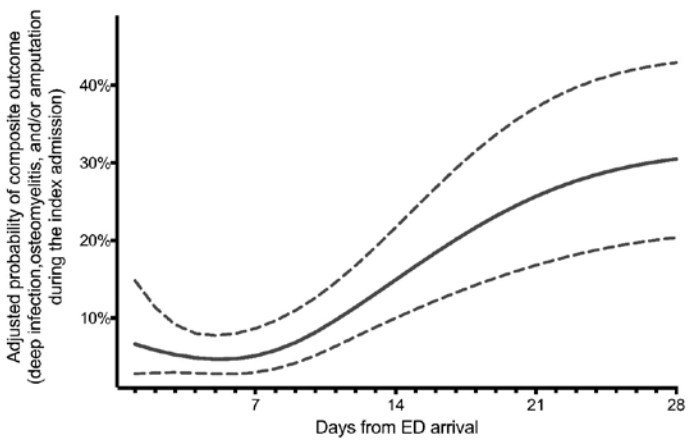
Purpose: This study was conducted to measure time to flap coverage after open tibia fractures and assess whether delays are associated with inpatient complications.

Methods: Data were derived from participating Trauma Quality Improvement Program (TQIP) centers between 2012 and 2015. Adults undergoing surgery for (1) an open tibia fracture and (2) a soft-tissue flap were eligible. The primary exposure was time from hospital arrival to definitive flap coverage (in days). The primary outcome was a composite of the following complications during the index admission: deep infection, osteomyelitis, and/or amputation. The primary analysis compared early and delayed coverage groups (≤7 and >7 days, respectively) after matching on propensity scores. We also modeled time to flap coverage as a continuous variable with logistic regression and cubic splines.

Results: There were 672 patients at 140 centers included, of which 412 (61.3%) received delayed coverage (>7 days). After matching, delayed coverage was associated with a significant increase in complications (16.7% vs 6.2%, P <0.001, NNH [number needed to harm] = 10). The duration of delay was also associated with an increasing risk (adjusted odds ratio [OR] 1.45, 95% confidence interval [CI] 1.27 - 1.66, per week coverage was delayed, P <0.001).

Conclusion: This is the first multicenter study of flap coverage for open tibia fractures. Complications rose significantly when flap coverage was delayed beyond 7 days, consistent with current guideline recommendations. Since the majority of patients did not receive coverage within this time frame, quality improvement initiatives are required.

Relationship between timing of flap coverage and the adjusted probability of the composite outcome. Probabilities (with 95% CIs) were modeled using adjusted cubic splines.



See pages 401 - 442 for financial disclosure information.

Treatment of Bone Defects in Open Tibia Fractures Treated with an Intramedullary Nail

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Purpose: This investigation intended to evaluate a cohort of patients with bone loss after open tibia fractures. We also test a definition of a critical size defect (> 2.5 cm mean) with respect to secondary grafting and major secondary procedures to the aprioi definition of > 1 cm and > 50% cortical loss up to 2.5 cm.

Methods: 18 centers reported patients ≥ 18 yo with open tibia fractures (OTA 42) with an IMN over 5 years. Data was tabulated for patients with a bone defect of > 1 cm and ≥50% cortical loss. Patients were followed for 13 months. Secondary procedures including bone graft, revision fixation, and flap coverage were modeled to estimate the number of expected secondary procedures. This analysis was performed for the group as a whole and also for those with and without a defect (>2.5 cm). Complications were analyzed using Kaplan Meier analysis. Union was assessed using the mean modified RUST (mRUST) score for 3 surgeons. An mRUST score of > to 9.5 has been validated as a reliable assessment of union. 123 had a final X-Ray for the mRUST.

Results: 132 patients, age 36 ± 14 with a mean defect size of 2.6 ± 1.9 cm were followed for 302 ± 89 days. 31% had flap coverage. 34% had a defect > 2.5 cm (avg 4.5 ± 1.9 cm) and the other 87 did not (avg 1.6 ± .57 cm). Some type of grafting was performed in 48% patients at an average of 119 ± 95 days after definitive fixation. Grafts used were autograft alone (44%), autograft with allograft with or without orthobiologics (41%), and allograft alone (11%). 40% grafts used an orthobiologic. PMMA was used in only 16% of cases. The expected number of procedures was 1.45 (95% CI: 1.12 – 1.85) and 1.02 (95% CI: 0.81 - 1.25) for those with and without defects > 2.5 cm, respectively. The risks of complications by 13 months were: infection 14%, amputation 7%, and flap failure 12%. Grafts were used in 58% of those with a defect (> 2.5 cm average) and 42% of those without (p=0.1). Mean mRUST scores were 10.7 for all groups.

Conclusion: This high risk group had 31% requiring flap coverage; salvage was possible in 93% with a 14% infection and 12% flap failure rate. A variety of grafting material was utilized. The expected secondary surgery events within 12 months was higher for the larger defects (1.45 vs 1.02; p=0.03). In patients who had a defect (>2.5 cm mean of four cortices) only 58% had a graft of some kind. 42% of patients with a defect using the criteria (> 1cm and > 50% diameter to < 2.5 cm) had a bone graft in the first year.

Predictors of Complications in Severe Open Fractures

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Purpose: Type IIIA open fractures represent a wide spectrum of injuries and are associated with substantial risk of complications that may be quite consequential in patients' overall outcomes. The purpose of this study is to determine the rate of complication requiring reoperation among Gustilo type IIIA open fractures and identify modifiable and nonmodifiable risk factors associated with reoperation.

Methods: This is a secondary analysis of the FLOW (Fluid Lavage in Open Wounds) trial, which is a multicenter prospective randomized controlled trial that evaluated the effect of different irrigation pressures and irrigation solutions in patients with open extremity fracture. The current analysis is restricted to the subset of patients originally enrolled in the FLOW trial who sustained Gustilo type IIIA fractures, which represents 649 patients. The primary outcome measure was complication requiring reoperation for wound-related and/or bone-related complications. Variables evaluated for association with the primary outcome were based on clinical rationale and previous analysis of the entire FLOW cohort.

Results: 125 patients (19.3%) underwent reoperation for complication, resulting in 273 reoperations (mean 2.2 per patient). Of these, 71% were wound-related, 25% were bone-related, and 5% were for other complications. In univariate analysis, reoperation was associated with incisional wound vacuum-assisted closure (VAC), severe contamination, lower extremity injury, wound size >10 cm^2, definitive external fixation, and wounds requiring multiple debridements. Application of antiseptic dressing in the Emergency Department was associated with decreased reoperation rate. In multivariate analysis, independent predictors included use of incisional wound VAC, severe contamination, and lower extremity injury.

Conclusion: Complication rates in Gustilo type IIIA fractures remain high at 20%. Consistent with previous studies, severe wound contamination and lower extremity injury were associated with complications. However, the current analysis also extends previous research by identifying the association between use of incisional wound VAC and increased complications. This represents a potentially modifiable treatment decision that warrants further investigation in future trials.

See pages 401 - 442 for financial disclosure information.

Wound Infections Following Implant Removal Below the Knee: The Effect of Antibiotic Prophylaxis: Results of the WIFI Trial, A Multicenter Randomized Controlled Trial

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Purpose: Following clean surgical procedures, the rate of postoperative wound infection (POWI) should be less than ~2%. However, a 12.2% infection rate has been reported following implant removal after foot, ankle, and lower leg fractures. The aim of this study was to evaluate the effect of a single dose of antibiotic prophylaxis on the incidence of wound infection following implant removal below the knee.

Methods: This study was a multicenter double-blind placebo controlled randomized trial in patients undergoing implant removal following a foot, ankle, or lower leg fracture. Patients were randomized between a single dose of intravenous cephalosporin and a placebo. Primary outcome was POWI. With 2 × 250 patients, a reduction in POWI rate from 10% to 3.3% could be detected.

Results: 470 patients were available for analysis with 228 patients in the intervention group and 242 patients in the control group. 66 patients developed a POWI (14.4%). In the intervention group 30 patients (13.2%) suffered from POWI versus 36 (14.9%) in the control group (P = 0.599). The only factor significantly associated with the development of POWI was use of alcohol (P = 0.048). No other possible risk factors were identified.

Conclusion: No evidence of treatment efficacy has been shown and we therefore believe there is no place for routine administration of a single dose of antibiotic prophylaxis prior to implant removal below the level of the knee.

Screening for and Treating Intranasal Staphylococcus Carriage Correlates with Reduced Surgical Site Infections Complicating Operative Fracture Repair

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Purpose: Preoperative intranasal mupirocin has been shown to decrease postoperative *Staphylococcus aureus* infections in colonized elective orthopaedic surgery patients, but this effect has not been investigated in orthopaedic trauma patients. We evaluate the association of a nasal *S. aureus* screening and treatment protocol with surgical site infection incidence among orthopaedic trauma patients undergoing operative treatment of acute fractures.

Methods: We conducted a retrospective cohort study including adult patients who sustained an acute pelvic or extremity fracture undergoing operative repair at a single university-affiliated Level I trauma center between 2012 and 2015. During this period all patients were screened for nasal *S. aureus* and those with positive cultures or those whose results were pending at time of surgery were treated with intranasal 2% mupirocin ointment for 5 days. Patients with at least 90 days of follow-up were matched one-to-one with historical controls presenting prior to the screening program based on fracture location (OTA fracture class) and fracture type (open or closed). The primary outcome was surgical site infection defined as infection requiring readmission and reoperation within 90 days of initial surgery.

Results: 268 screened patients treated definitively for an acute pelvic or extremity fracture were included and matched to 268 control subjects. 26 (10%) had positive *S. aureus* nasal swab and were treated. In the screened group, 14 patients (5%) developed surgical site infections requiring readmission and reoperation within 90 days, compared to 24 (9%) in the control group ($P = 0.092$). Current smoking and diabetes were associated with infection and adjusted for in a multivariable analysis showing that nasal *S. aureus* screening was associated with 0.34 (95% confidence interval 0.13-0.88) the odds of infection, $P = 0.027$.

Conclusion: Implementation of a screening and treatment protocol for intranasal *S. aureus* was associated with a reduction in surgical site infection requiring reoperation after operative pelvis and extremity fracture repair. A larger prospective clinical trial is required to confirm the effectiveness of this program in reducing surgical site infections in an orthopaedic trauma population.

See pages 401 - 442 for financial disclosure information.

Decreased Time to Antibiotic Prophylaxis for Open Fractures at a Level One Trauma Center

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Purpose: Open fractures present a unique treatment dilemma to orthopedic surgeons. Prophylactic antibiotics have been shown through multiple studies to decrease the incidence of infection in open fractures. Our study seeks to determine whether time to administration of antibiotics decreased following the implementation of an open fracture working group at a Level I trauma center.

Methods: 50 consecutive patients were enrolled prior to the implementation of our working group, and 50 patients were enrolled following the implementation of our working group. Age, gender, type of fracture, time of admission, time of ordering antibiotics, and time of administration of antibiotics were all recorded. Upon the initiation of our working group, we started an educational conference with Emergency Medicine (EM) providers about the importance of antibiotic prophylaxis for open fractures, our pharmacy began premixing bags of cephazolin, we altered the trauma ordering system to ease ordering of antibiotics for trauma patients, and posted educational posters throughout the Emergency Department. Standard descriptive statistics were used, chi-squared tests were used to evaluate categorical variables, and paired t tests were used to analyze for statistical significance of time differences pre- and post-protocol; significance was set to $P < 0.05$ a priori.

Results: After protocol implementation, time from admission to antibiotic administration decreased significantly from 123.1 to 35.7 minutes, 87.4 minutes shorter (71.0% sooner, $P = 0.0003$). Each component also decreased significantly: admission to order decreased 72.3% from 94.1 to 26.1 minutes, and order to administration decreased 67.0% from 29.0 to 9.5 minutes ($P = 0.0046$ and $P = 0.0003$, respectively).

Conclusion: Administration of prophylactic antibiotics has been demonstrated to reduce the risk of infection following open fractures in several large studies. While the idea that the antibiotics should be given for prophylaxis as early as possible has long been accepted based on animal models, only recently was the time point of 65 minutes after injury shown to be an independent risk factor for infection following type III open tibia fractures. Our study demonstrates a significantly reduced time to antibiotic prophylaxis for patients with open fractures following the implementation of a multidisciplinary working group. We hope that this provides a model for other institutions to improve care and outcomes of these challenging injuries.

Diagnostic Accuracy of Various Modalities Relative to Open Bone Biopsy for Detection of Long Bone Posttraumatic Osteomyelitis

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Purpose: Long bone posttraumatic osteomyelitis (PTOM) is a relatively common complication following surgical fixation of open fractures. Consensus is lacking as to ideal strategies for diagnostic evaluation of long bone PTOM. While open bone biopsy and culture is considered the "gold diagnostic standard," its cost and invasiveness are often prohibitive and have prompted the search for alternate diagnostic methods. The purpose of this study was to evaluate the sensitivity and specificity of various diagnostic modalities relative to open bone biopsy and culture for the detection of long bone PTOM.

Methods: A consecutive cohort of 159 adult patients presenting with long bone PTOM at our Level I trauma center between January 1, 2004 and December 31, 2013 were retrospectively identified. All included patients fulfilled diagnostic criteria for PTOM (as defined by the Centers for Disease Control and Prevention) that involved a long bone (femur, fibula, tibia, humerus, radius, and ulna). Patients with diabetic foot infection, septic arthritis, osteomyelitis of the spine/pelvis/hand, or insufficient medical records were excluded. Sensitivity and specificity of deep wound culture, soft-tissue histopathologic examination, and elevated levels of acute phase reactants (C-reactive protein [CRP], erythrocyte sedimentation rate [ESR], and leukocyte count [WBC]) were determined using findings of open bone biopsy and culture as a reference standard.

Results: The most common pathogen isolated on open bone culture was Staphylococci, contributing to 89 (57%) of 159 cases of long bone PTOM ($P < 0.001$). Relative to open bone biopsy and culture as the gold diagnostic standard, soft-tissue histopathology demonstrated a sensitivity of 69.8% (95% confidence interval [CI], 53.7-82.3%) and specificity of 38.9% (95% CI, 18.3-63.9%) for the detection of long bone PTOM. Deep wound culture exhibited a lower sensitivity of 66.0% (95% CI, 56.1-74.8%) and specificity of 28.1% (95% CI, 12.9-49.5%), a difference that was statistically significant ($P = 0.021$). Among inflammatory markers, elevated levels of CRP and ESR were equally sensitive for the detection of PTOM compared to open bone biopsy and culture, while WBC was significantly less sensitive (sensitivity, 33.2%; 95% CI, 25.3-43.7; $P < 0.001$).

Conclusion: Soft-tissue histopathologic examination, deep wound culture, and measurement of acute phase reactants are relatively poor substitutes for the diagnosis of long bone PTOM compared to open bone biopsy and culture. The accurate identification of causative pathogens underlying long bone PTOM is critical for diagnosis and choice of antibiotic treatment. Future studies investigating the use of higher-resolution diagnostic methods are merited.

See pages 401 - 442 for financial disclosure information.

Significant Reduction of Intraoperative Material Costs Through Surgeon Intervention

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Purpose: Reducing costs in health care is becoming increasingly important. Surgeons have the ability to modulate operating room costs through choice of implants and disposable items, but it is not clear how much of an impact surgeons might have. Our hypothesis was that surgeon identification and modification of practices responsible for intraoperative cost variation would lead to significant cost reductions.

Methods: This was a prospective observational study of 6 orthopaedic trauma subspecialists at a Level I trauma center using retrospectively collected control data from the same surgeons. Control data included all operatively treated bimalleolar ankle fractures (BAFs) and bicondylar tibial plateau fractures (BTPFs) from 2013 to July 2014 (19-month period) (Group 1). Operative sessions involving multiple procedures were excluded to avoid including costs of unrelated procedures. Using operating room inventory software, we created a spreadsheet displaying all itemized surgical costs for each procedure. Operative notes and radiographs were reviewed to confirm accuracy of the spreadsheets. From August 2014 to October 2014 (3-month "transition" period), the 6 surgeons evaluated the cases to determine sources of high cost and differences between the surgeons. The surgeons met for an evidence-based discussion of variations in treatment and the associated cost differences. Surgeons modified their surgical practices accordingly. A similar spreadsheet was generated for cost analysis from November 2014 through 2015 (14-month period) (Group 2). Operative costs of Group 1 were compared to Group 2. BAFs were analyzed separately from BTPFs. Statistical analysis utilized the Mann-Whitney U test as cost data were not normally distributed.

Results: Group 1 included 88 BAFs and 46 BTPFs. Group 2 included 82 BAFs and 43 BTPFs. Median cost of BAF decreased from $676 to $532 ($P = 0.0001$), and median cost of BTPF decreased from $2515 to $2184 ($P = 0.011$). Mean cost reductions were more substantial due to reduction in outlier cases. BAF mean decreased from $1099 to $775. BTPF mean decreased from $3219 to $2184.

Conclusion: We found significant operating room material cost reductions for BAF and BTPF. Cost distributions clustering more tightly around the median costs in Group 2 suggests increased uniformity of treatment strategies by the 6 surgeons. Further research to demonstrate maintenance of clinical outcomes in this scenario is warranted.

Operative Treatment of Tibial Plateau Fractures: Does a Submeniscal Arthrotomy Improve Long-Term Patient Outcome? A Prospective Surgeon Randomized Clinical Trial

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Purpose: This trial was conducted to determine the long-term functional outcome (>2 years) of displaced tibial plateau fracture patients treated with closed fluoroscopic-assisted reduction and internal fixation (CRIF) versus patients treated with standard open reduction with submeniscal arthrotomy and internal fixation (ORIF).

Methods: A prospective trial was conducted by accruing all patients between 18 and 70 years old with displaced AO/OTA 41B and 41C tibial plateau fractures. Sample size was chosen based upon the primary outcomes, KOOS (Knee Injury and Osteoarthritis Outcome Scale), with 12 points of difference, which would consist of 28 patients in each treatment arm (P = 0.05, power = 80%). Patients were randomized to treatment based upon the standard treatment of the surgeon involved following the call schedule for the day, either CRIF or ORIF. Postoperative CT was performed on all patients and they were followed for a minimum of 2 years. Primary outcome measures were the KOOS, Short Musculoskeletal Function Assessment (SMFA), and Short Form-36 (SF-36).

Results: 70 patients were recruited (62 patients were able to be followed for a minimum of 3 months and then up to the complete 2 years) with 35 patients in the CRIF group and 27 patients in the ORIF group. The CRIF group left hospital 1 day earlier. Postoperative CT scans showed that reductions were more satisfactory with the ORIF group especially in the posterolateral quadrant as compared to the CRIF group. The frequency of malreductions (>2 mm step or gap) in patients undergoing submeniscal arthrotomy versus fluoroscopic-assisted reduction was 16.6% and 41.4%, respectively (P = 0.002). The KOOS, at 2 years, showed that the CRIF had significantly less good outcomes in the subcategory quality of life (QoL) measurement (P = 0.01). Two-year follow-up showed that clinical alignment, radiographic reduction, patellofemoral crepitus, and condylar width were not significantly different (P >0.05).

Conclusion: The CRIF group achieved the same quality of reductions except in the posterolateral quadrant of the tibial plateau, where it is was 7 times (odds ratio 7.2) more likely to malreduce the tibial plateau. Despite recent trends towards less invasive surgery, it is recommended that for displaced tibial plateau fractures, ORIF with submeniscal arthrotomy provides better long-term results (minimum of 2 years) as compared to closed reduction and fluoroscopic-assisted reduction.

See pages 401 - 442 for financial disclosure information.

Sleep Disturbance in Orthopaedic Trauma Patients

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Purpose: This study was undertaken to evaluate the prevalence and severity of sleep disturbance experienced by orthopaedic trauma patients, how sleep disturbance affects the patients' perceived health quality, and identify factors associated with sleep disturbance.

Methods: This is an IRB-approved, cross-sectional cohort study of patients seen in the orthopaedic trauma clinic of a large community hospital in a metropolitan area. After obtaining written consent, qualified patients were given Pittsburgh Sleep Quality Index (PSQI) and 36-Item Short Form Survey (SF-36) questionnaires in their primary language. Inclusion criteria included orthopaedic injury, age ≥18 years, and ability to read English and/or Spanish. For this study, we used PSQI ≥5 as indicative of sleep disturbance. Demographic data, as well as ISS at time of presentation, were recorded.

Results: 335 patients were included. 288 patients (86.0%) had a PSQI score ≥5, indicating the presence of sleep disturbance. The PSQI score was ≥10 in 183 patients (54.6%), which is sleep disturbance similar to the level seen in clinical depression. The average PSQI score was 10.3 (±4.8). Patients reported an average sleep latency of 38.9 (±37.5) minutes, with a total nightly sleep time of 6.3 (±1.9) hours. After multivariate analysis, the bodily pain (BP), vitality (VT), and mental health (MH) components of the SF-36 remained independently associated with PSQI (P = <0.001, 0.002, and 0.001, respectively). ISS measurements at time of presentation and time since injury or surgery did not correlate with PSQI scores.

Conclusion: Our study is the first of its kind to objectively evaluate sleep disturbance in an orthopaedic trauma population. Our findings suggest that sleep disturbance is both highly prevalent (86% PSQI ≥5) and severe (54.6% PSQI ≥10) in patients recovering from an orthopaedic trauma injury. The BP, VT, and MH components of the SF-36 were independently associated with worse sleep quality. The average orthopaedic trauma patient presents with a sleep score similar to that seen in sleep disorders and clinical depression. Interestingly, in our study, the severity of the overall injury burden as measured by ISS and time since injury did not correlate with the severity of sleep disturbance, as one might expect.

Inpatient Compliance with Venous Thromboembolism Prophylaxis in Orthopaedic Trauma: A Pragmatic Randomized Controlled Trial of Aspirin Versus Low Molecular Weight Heparin

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Purpose: It is unknown if aspirin (acetylsalicylic acid [ASA]) or enoxaparin (low molecular weight heparin [LMWH]) is the more efficacious venous thromboembolism (VTE) prophylaxis after orthopaedic trauma. Missed doses are associated with increased VTE, and patient refusal is a common reason for missed doses. We sought to compare inpatient compliance with these 2 regimens and identify risk factors for noncompliance.

Methods: We conducted a pragmatic randomized controlled trial of adults presenting to a Level I trauma center with an operative extremity fracture proximal to the tarsals/carpals or any pelvic or acetabular fracture requiring VTE prophylaxis. Patients were randomized to receive either LMWH 30 mg BID or ASA 81 mg BID for the duration of indicated prophylaxis. Our primary outcome measure was the percentage of doses received compared to the ideal number of doses. Of 483 patients who met study exclusion/inclusion criteria, 329 patients (68.1%) consented to enroll in the IRB-approved study: 165 randomized to ASA and 164 to LMWH.

Results: There was no difference in percentage of patients who missed a dose (ASA: 41.2% vs LMWH: 43.3%, P = 0.7) or mean number of missed doses (0.6 vs 0.7 doses, P = 0.4) between arms. The majority of patients (57.8%, n = 190) did not miss any doses. Only 6.4% (n = 21) of patients had their assigned prophylaxis stopped with no significant difference between arms (P = 0.1). Reasons for missed doses and refusal rates were similar, except only patients in the aspirin arm missed doses due to inability for enteral medication administration (10.3% vs 0%, P <0.01). Patients with upper extremity injuries (odds ratio [OR]: 1.99; 95% confidence interval [CI]: 1.20-3.30; P = 0.01) were more likely to miss a dose. Finally, 10.6% of patients (n = 35) received at least 1 dose of the non-assigned prophylaxis regimen postrandomization without a medical indication but there was no significant difference in rates between treatment arms (P = 0.6).

Conclusion: Inpatient adherence was similar for ASA and LMWH. Missed doses were most often associated with an operative procedure; however, patient refusal and inability to give enteric medications also contributed. Interestingly, compliance rates varied with fracture patterns. These data should help reassure clinicians that these medicines have similar inpatient compliance and prove crucial to investigators designing larger trials to explore efficacy of these medicines.

See pages 401 - 442 for financial disclosure information.

Tranexamic Acid Use in High-Energy Pelvic, Acetabular, and Femoral Fractures

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Purpose: Tranexamic acid (TXA) inhibits clot break down by binding plasminogen and preventing conversion to plasmin. TXA decreases transfusion requirements in hip fracture surgery and elective arthroplasty without increased the risk of venous thromboembolic events (VTE). Use of TXA has not been evaluated in the setting of high-energy fractures in the pelvis or femur. The purpose of this study was to assess the efficacy and safety of TXA in such fractures. We hypothesized that TXA would decrease total blood loss and transfusions in patients with these fractures.

Method: A prospective, randomized controlled trial was performed of TXA use in patients with isolated closed pelvic and femur fractures treated with open reduction and internal fixation and expected EBL>300 mL. 100 patients were randomized into two groups. Exclusion criteria included pregnancy, oral contraceptives, contraindication to VTE prophylaxis, operation for another injury, hypercoagulable state, and renal insufficiency. The treatment group received IV TXA in two 15mg/kg doses: one at incision and another 3 hours later. The control group did not receive the medication. A transfusion trigger of hemoglobin (Hgb) <8 g/dL was used in healthy patients. Patients with symptomatic anemia were transfused regardless of Hgb level. Low molecular weight heparin was used for VTE prophylaxis. Data analyzed included demographics, AO/OTA fracture classification, pre- and postoperative Hgb/Hct, number of pRBC units transfused, EBL, total blood loss, and VTE. Primary outcome measures were total blood loss (by Hgb dilution method), change in preoperative to postoperative hematocrit values, and units of pRBCs transfused.

Results: After post-randomization exclusions, 84 patients were analyzed. Forty-four patients received TXA, and 40 patients were controls. TXA group had a lower average preoperative Hct but this was not significant (TXA=34.1, No TXA=35.6, P=0.22). EBL was higher in the TXA group, but this did not reach significance (P=0.28). The number of intraoperative units transfused was not significantly different between groups (TXA=1.32, No TXA=0.54, P=0.051). Control patients were twice as likely to receive a postoperative transfusion (cOR= 1.91, P=0.22), but this association was not statistically significant. Average drop in Hct from preop to postop day 1 was significantly greater (P=0.02) in the control group (-5.43 ± 3.77) than in the TXA group (-2.88 ± 5.70). Total blood loss was higher in the control group but this was not significant (TXA=880mL, No TXA=1010mL, P=0.44). There were no significant differences between the TXA and control groups in inpatient VTE events.

Conclusion: The use of TXA in high-energy fractures of the pelvis and femur may decrease total blood loss and postoperative transfusion. TXA did not increase the rate of VTE. These data show trends toward improved blood conversation, but further study is warranted prior to making broad recommendations for use of TXA in these fractures.

How to Best Measure Changes in Clinical Status over Time: An Analysis of the Performance of Generic and Musculoskeletal Specific Functional Outcome Measures in Single Injury and Multiply Injured Patients

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Purpose: Patient-reported outcome measures (PROs) are the gold standard for assessing outcomes in orthopaedic trauma, but if multiple measures are used they can be a significant burden. Previous studies into specific injuries identified the Short Form-36 (SF-36) as the most responsive PRO and suggested that the Short Musculoskeletal Function Assessment (SMFA) may be unnecessary, but no studies have looked at multiple versus isolated injuries.

Methods: 659 patients were identified from prospective studies into operatively treated lower limb fractures, of whom 485 had isolated and 174 multiple injuries. For each group we assessed the responsiveness of the SF-36 and SMFA by calculating the standardized response mean (SRM), the proportion meeting minimal clinically important difference (MCID) between time points, and floor and ceiling effects.

Results: Between baseline and 6 months, the SRM of SF-36 was consistently greater than that of SMFA for both groups of patients. Between 6 and 12 months, the SRM for the SF-36 was greater in single injury patients. The proportion of patients who achieved MCID was consistently higher for SF-36 compared with SMFA. No ceiling effects were observed. However, at baseline, floor effects were seen in SMFA scores for both groups. No floor effects were seen at follow-up.

Conclusion: This study demonstrates that SF-36 has superior responsiveness versus SMFA in both isolated and multiple injury patients and supports the collection of SF-36 as the primary PRO irrespective of whether the patient has other injuries.

	Isolated Trauma (n=485)							Polytrauma (n=174)						
	SF-36 PCS			SMFA DI			SRM p-value	SF-36 PCS			SMFA DI			SRM p-value
Score Improvement	Mean	SD	SRM	Mean	SD	SRM		Mean	SD	SRM	Mean	SD	SRM	
Baseline to 6 months	-15.5	10.93	-1.42	-11.18	10.90	-1.03	<0.0001	-20.39	11.95	-1.71	-18.10	13.43	-1.35	<0.01
6 months to 12 months	4.62	7.95	0.58	3.09	6.17	0.50	<0.0001	4.45	7.40	0.80	4.43	7.63	0.58	0.98

Table 1: Standardized Response Mean for Isolated Trauma and Polytrauma

		SF-36 PCS		SMFA DI		p-value
		MCID	Number achieving (%)	MCID	Number achieving (%)	
Baseline to 6 months	Isolated Trauma	5.47	395 (81.44)	5.45	323 (66.66)	<0.0001
	Polytrauma	5.97	144 (82.76)	6.72	134 (77.01)	0.11
	All	5.70	539 (81.79)	6.00	449 (68.13)	<0.0001
6 months to 12 months	Isolated Trauma	3.97	304 (62.68)	3.08	278 (57.32)	0.07
	Polytrauma	3.70	111 (63.79)	3.82	97 (55.75)	0.10
	All	3.90	417 (63.28)	3.30	365 (55.39)	<0.01

Table 2: Numbers achieving minimal clinically important difference

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Early Effects of the Trauma Collaborative Care Intervention: Results from a Prospective Multicenter Cluster Clinical Trial

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Purpose: The Trauma Collaborative Care (TCC) program was developed to improve the psychosocial sequelae postinjury. TCC includes the Trauma Survivors Network (TSN) services and TSN coordinator activities to support collaborative care. The impact of the TCC early intervention components (education, peer visits, and coaching calls) on 6-week outcomes was evaluated in a prospective, multicenter, cluster clinical trial.

Methods: Outcomes of 481 patients at 6 trauma centers implementing the TCC program were compared with those of 419 patients at 6 trauma centers receiving usual care. Eligible patients had high-energy orthopaedic trauma injuries requiring surgery and hospital admission. Binary outcomes (pain [0-10] ≥5, Patient Health Questionnaire [PHQ]-9 depression ≥10, Posttraumatic Stress Disorder Checklist [PTSD PCL] ≥30 and self-efficacy [0-10] for return to work ≥7) were analyzed using a Bayesian hierarchical modeling approach to estimate the intention-to-treat effect. We also estimated the effect had all patients received all components of the intervention. Using the Bayesian formalism, 95% credible intervals and posterior probabilities of a favorable treatment effect are reported.

Results: Of the 481 intervention patients, 371 (77%) received a TSN Handbook, 279 (58%) received a peer visit, and 308 (64%) received ≥1 coaching call prior to 6-week assessment. There was substantial variation across the 6 sites in receipt of intervention components. Only 36% of intervention patients received all 3 components (range, 18% to 77%). The posterior estimates of the intention-to-treat effect (odds ratio scale) for all end points favor TCC; however, the credible intervals all include one. For pain and depression, there is 93.3% and 96.4% posterior probability that the TCC program has a favorable effect, respectively. Had all patients received all components of the intervention the estimated effect more strongly favors positive effects of the TCC program. For depression and self-efficacy, the 95% credible intervals exclude one with posterior probabilities of 98.7% and 98%. For pain and PTSD, the 95% credible intervals include one, but the posterior probabilities of a favorable effect are high (97.1% and 95.8%, respectively).

Conclusion: Use of the services offered through the TCC program was highly variable across sites. While there is a suggestion of an intention-to-treat effect on pain, depression, PTSD, and self-efficacy, the results are not statistically significant. Had early components been fully implemented, analysis suggests that the TCC program may lead to significantly lower levels of clinical depression and higher levels of self-efficacy at 6 weeks after injury; there is also a promising effect on pain and PTSD.

Predicting Completion of Follow-up in Prospective Orthopaedic Trauma Research

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Purpose: Orthopaedic trauma studies that collect long-term outcomes are expensive and maintaining high rates of follow-up can be challenging. Knowing what factors influence completion of follow-up could allow interventions to improve this, but few studies have been published looking at this. We theorized that factors such as work status and social assistance would be potential predictors for completing follow-up to 12 months.

Methods: Patients who had previously been recruited to 4 studies into orthopaedic trauma inpatients at our Level I trauma center were included. Their orthopaedic injuries were all managed operatively and outcome questionnaires including Short Form-36 (SF-36) and Short Musculoskeletal Function Assessment (SMFA) were collected at baseline, 6 months, and 12 months. Complete follow-up was defined as completion of all outcome measures at all time points up to 12 months. Univariate analysis and subsequent analysis by building a reductive multivariate regression model allowed for estimation of the influence of factors in completion of follow-up.

Results: 870 patients with complete data had previously been recruited and were included in the analysis. 707 patients (81.2%) completed follow-up to 12 months. Factors associated with completion of follow-up included the physical component summary score of SF-36 at baseline, not being on social assistance at the time of injury, being married, and having a higher level of educational attainment (Table 1).

Conclusion: Although these factors are not modifiable themselves, we advocate that researchers planning longitudinal orthopaedic trauma studies should take these factors into account in their design.

	Odds Ratio	95% Confidence Intervals		p-value
		Lower	Upper	
SF-36 PCS Score at baseline	1.032	1.010	1.055	**0.004**
Educational Attainment (versus those who didn't graduate high school)				
Graduated High School	1.231	0.743	2.032	0.418
Some College Education	1.732	1.018	2.950	**0.043**
Graduated College	1.633	0.975	2.731	0.061
Postgraduate degree	2.112	1.207	3.722	**0.009**
Marital Status (versus married patients)				
Living with significant other	0.493	0.301	0.809	**0.005**
Divorced/separated	0.790	0.454	1.402	0.410
Widowed	0.693	0.287	1.804	0.428
Single	0.568	0.382	0.839	**0.005**
Not currently working vs. working	0.733	0.529	1.018	0.063
No social assistance vs. social assistance	2.227	1.348	3.671	**0.002**

Table 1: Results of multivariate regression analysis

See pages 401 - 442 for financial disclosure information.

A Randomised Controlled Trial Comparing the Thompsons Versus the Exeter® Polished Taper Stem and Unitrax® Head in the Treatment of Displaced Intracapsular Fractures of the Hip: The WHiTE 3: HEMI Trial

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Purpose: Our objective was to compare the change in health-related quality of life of patients receiving a traditional cemented monoblock Thompson hemiarthroplasty versus a modern cemented modular polished taper stem hemiarthroplasty for displaced intracapsular fractures of the hip.

Methods: This was a pragmatic, multicenter, multisurgeon, 2-arm, parallel group, randomized standard-of-care controlled trial. It was embedded within the WHiTE (World Hip Trauma Evaluation) Comprehensive Cohort Study. The trial was conducted on an intention-to-treat (ITT) basis. Five NHS trauma centers in England, UK undertook patient recruitment. The sample size was 964 patients. Hip fracture patients presenting to participating trusts between February 2015 and March 2016, over 60 years of age, and requiring hemiarthroplasty of the hip were eligible for recruitment. The main outcome measure was the EQ-5D-5L questionnaire, carried out on admission and at 4 months postoperation.

Results: The adjusted EQ-5D-5L at 4 months excluding mortality is 0.045 (95% confidence interval [CI] -0.007 to 0.098); P = 0.09. This decreases to 0.037 (95% CI -0.014 to 0.087; P = 0.156) when mortality is included. The minimum clinically important difference for EQ-5D-5L used in this study is 0.08; therefore any benefit between implants is unlikely to be noticeable by the patient. There is no difference in mortality or mobilization at this time point. There is a small benefit in length of stay in favur of the Exeter stem with a Unitrax head during the initial hospital admission.

Conclusion: Contrary to the current NICE (National Institute for Health and Clinical Excellence) Hip Fracture Guidelines, the use of the traditional Thompson hemiarthroplasty in the treatment of the displaced intracapsular hip fracture shows no difference in comparison to the recommended modern cemented hemiarthroplasty.

THR Versus Hemiarthroplasty for Displaced Intracapsular Fractures: Predicting Outcomes and Selecting Patients

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Purpose: In the UK, the National Institute of Health and Care Excellence (NICE) recommends offering total hip replacement (THR), rather than hemiarthroplasty, for displaced intracapsular hip fractures (OTA 31 B3, Garden 3-4) in patients who can walk independently outdoors, who are not cognitively impaired, and who are medically fit for anesthesia and the procedure. However, many centers perform THR on only a small proportion of "eligible" patients. This study aimed to compare outcomes after hemiarthroplasty or THR for displaced intracapsular hip fractures and suggest a simple method of identifying the most suitable patients for THR.

Methods: A search of the regional trauma center inpatient database identified all patients treated with hemiarthroplasty or THR for displaced intracapsular hip fracture from 4 January 2011 to 4 August 2014, with admission data on age, American Society of Anesthesiologists (ASA) grade, mini-mental state examination (MMSE, maximum score 10), mobility and function (Barthel score, maximum score 20). All surviving patients had telephone follow-up to 1 year. Patients with the ability to "walk alone outdoors" (WAO), MMSE of 8-10, and ASA grade 1-3 were deemed to meet eligibility criteria for THR.

Results: The search identified 1654 patients including 1506 (91%) hemiarthroplasty and 148 (9%) THR patients. 20% of these hemiarthroplasty patients (295 patients) met eligibility criteria for THR. Among patients with ASA grades 1-3, THR patients were significantly more likely to maintain the ability to WAO at 1 year than hemiarthroplasty patients ($P < 0.0001$). Cohorts of 50 hemiarthroplasty and 50 THR patients were matched for age, gender, mobility (all could WAO), full functional scores (all Barthel score 20), ASA grades (all ASA 1-3), and MMSE score (all 8-10). After matching groups, significantly more THR patients (90%) than hemiarthroplasty patients (46%) maintained the ability to WAO at 1 year ($P < 0.0001$). We have proposed a set of bedside questions to assess for suitability for THR, addressing NICE criteria, and whether the patient could climb stairs unaided preinjury, which implies a full Barthel score.

Conclusion: Mentally competent patients with OTA 31 B3 fractures, with prior ability to WAO, a full functional score, ASA 1-3, and comparable ages are significantly more likely to maintain the ability to WAO at 1 year after THR than hemiarthroplasty. These factors may be used to identify optimal patients for THR after such fractures.

See pages 401 - 442 for financial disclosure information.

Continuous Femoral Nerve Catheters Decrease Opioid-Related Side Effects and Increase Home Disposition Rates Among Geriatric Hip Fracture Patients

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Purpose: The purpose of the study was to evaluate the effect of continuous femoral nerve catheters (CFNCs) for postoperative pain control in geriatric proximal femur fractures compared to standard analgesia (SA) treatment.

Methods: We retrospectively identified 265 consecutive geriatric hip fracture patients who underwent surgical treatment at 1 academic Level I trauma center. 149 patients were treated with SA without nerve catheter while 116 patients received an indwelling CFNC. The main outcome measurements included daily average preoperative and postoperative pain scores, daily morphine equivalent consumption, opioid-related side effects, and discharge disposition.

Results: CFNC patients reported lower average pain scores preoperatively (1.9 ± 1.7 for CFNC vs 4.7 ± 2 for SA; P <0.0001), on postoperative day 1 (1.5 ± 1.6 for CFNC vs 3 ± 1.7 for SA; P <0.0001) and postoperative day 2 (1.2 ± 1.5 for CFNC vs 2.6 ± 2.1 for SA; P <0.0001). The CFNC group consumed 39% less morphine equivalents on postoperative day 1 (4.4 ± 5.8 mg for CFNC vs 7.2 ± 10.8 mg for SA; P = 0.005) and 50% less morphine equivalent on postoperative day 2 (3.4 ± 4.4 mg for CFNC vs 6.8 ± 13 mg for SA; P = 0.105). CFNC patients had a lower rate of opioid-related side effects compared to SA patients (27.5% for CFNC vs 47% for SA; P = 0.001). More CFNC patients were discharged to home with or without health services than SA patients (15% for CFNC vs 6% for SA; P = 0.046).

Conclusion: CFNCs decreased daily average patient reported pain scores and narcotic consumption while decreasing the rate of opioid-related side effects. CFNC patients were discharged to home more frequently. Based on these data, we recommend routine use of perioperative CFNCs in geriatric hip fracture patients undergoing surgery.

A Novel Tool to Predict Inpatient Triage and Hospital Quality Measures in the Geriatric Trauma Population at Time of Admission

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Purpose: We developed a novel geriatric trauma risk tool using patient variables including age, comorbidities, and anatomic injuries, which has been shown to have excellent capacity in predicting inpatient mortality. The purpose of this study is to investigate the efficacy of this trauma triage score in predicting measures of hospital quality, including lengths of stay, need for advanced level of care, inpatient complications, readmissions, and locations of disposition.

Methods: Patients 55 years and older who were evaluated in the emergency department setting by orthopaedic surgery at one academic medical center during the study period of October 1, 2014 to September 30, 2016 were prospectively enrolled. On initial evaluation, each patient's demographics, injury severity, and functional status were utilized to calculate a trauma triage score (STTGMA). Information on length of stay, complications during hospitalization, need for ICU/SDU (intensive care unit/step down unit) level care, and locations of disposition were collected. Patients were followed for 30 days to observe readmissions. Patients were stratified into minimal, low, moderate, and high-risk cohort groups based on inpatient mortality risk of 5%.

Results: A total of 1592 patients were prospectively enrolled in this study. 1278 patients (80.3%) sustained low-energy injuries and 314 patients (34.8%) sustained high-energy injuries. The average age was 73.8 ± 11.8 years. The mean length of hospital stay was 5.2 days with a significant difference between the STTGMA risk groups. In addition, the mean minor complication rate (0.33) and the mean major complication rate (0.16) were both greater in the moderate and high risk cohorts than in the lower risk cohort groups. Patients in the high-risk cohort had a higher risk of inpatient death ($P < 0.001$), requirement of ICU/SDU level care ($P < 0.001$), and unplanned readmissions within 30 days ($P < 0.001$). Lastly, there was a significant difference in the number of patients discharged home between the risk cohorts with 79.8% of the minimal risk cohort discharged home and 12.3% of the high-risk cohort ($P < 0.001$).

Conclusion: Not only is the STTGMA risk score predictive of inpatient mortality for middle age and geriatric patients who sustained trauma, but it also may be a valuable tool to predict inpatient triage and hospital quality measures. Thus, it is a valuable clinical tool for health-care providers in identifying high-risk patients in efforts to continue to provide high-quality resource-conscious care to orthopaedic trauma patients.

See pages 401 - 442 for financial disclosure information.

Any Femoral Neck Shortening Post Fracture Fixation Negatively Impacts Functional Outcomes

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Purpose: Previous research has suggested that femoral neck fracture shortening is associated with worse functional outcomes; however, prior studies have been limited by relatively small sample sizes, limited power to test the association across different shortening thresholds, and populations that mixed patients with uncomplicated healing and concomitant healing complications such as osteonecrosis. By using data from a large clinical trial, we sought to overcome previous research limitations and test the hypothesis that increasing fracture shortening is associated with worse hip function among patients with healed femoral neck fractures.

Methods: Patients with radiographic healing, as determined by a blinded adjudication committee, were extracted from the FAITH (Fixation Using Alternative Implants for the Treatment of Hip Fractures) multicenter trial data of elderly hip fracture patients. All patients received fixation with either a sliding hip screw or multiple cancellous screws. The primary outcome was hip function measured by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score at 2 years post surgery. All included fractures were categorized as no shortening, mild shortening (≤5 mm), moderate shortening (6-10 mm), or severe shortening (>10 mm). Linear regression was used to estimate the association between femoral neck shortening and hip function.

Results: 350 patients were included in the final analysis. 50% received a sliding hip screw and 50% received multiple cancellous screws. Overall, 38% of the patients healed with no shortening, 30% with mild shortening, 20% with moderate shortening, and 12% with severe shortening. After adjusting for type of reduction and surgical treatment, a greater amount of femoral neck shortening was found to be associated with poorer hip function ($p < 0.01$). When stratified by implant, shortening and hip function remained associated; however, in patients with cancellous screws, WOMAC scores increased as femoral neck shortening worsened, but in those with a sliding hip screw, WOMAC increased between the no and mild shortening groups and then decreased.

Conclusion: In this population, it was found that increasing femoral neck shortening was associated with worse hip function. However, we also found significant differences in hip function between patients treated with cancellous screws and those treated with a sliding hip screw, which was unexpected. While internal fixation often successfully achieves union, patients that heal in a shortened position report worse functional outcomes.

Gait Analysis Following Intertrochanteric Hip Fractures: Does Shortening Result in Gait Impairment?

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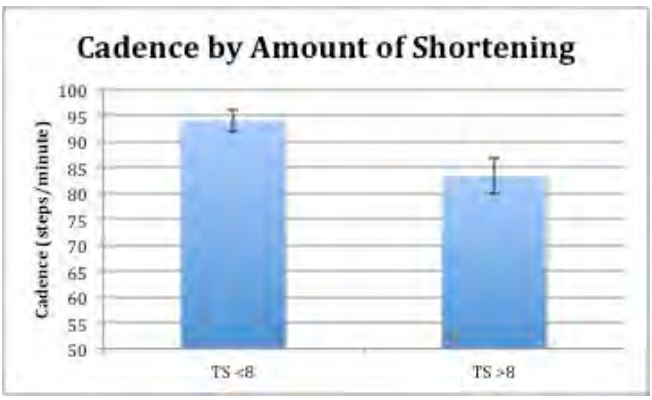
Purpose: The objective of this study was to determine risk factors for gait impairment following hip fracture fixation. We hypothesized that radiographic shortening and greater trochanter malunion would result in decreased cadence and increased double stance time.

Methods: Patients who sustained intertrochanteric (IT) fractures treated with cephalomedullary nailing between 2012 and 2016 were recruited to participate in the study. At follow-up appointments, temporospatial gait parameters were measured and recorded. Patients also completed the Harris hip score (HHS), visual analog scale (VAS) for pain, and the Short Form-36 Mental Component Summary and Physical Component Summary (SF-36 MCS and PCS) at each visit. Radiographs were analyzed at the time of surgery and at each follow-up visit. The amount of radiographic femoral neck shortening was measured after correcting for image magnification and rotation.

Results: A total of 76 patients were enrolled in the study and the mean age was 79.3 years. The mean amount of shortening was 4.8 mm (±0.6 mm). Patients with increased shortening demonstrated increased terminal double stance time (P = 0.002) and decreased cadence (P = 0.030) (Fig. 1). Patients with greater trochanteric malunions had lower HHS (P = 0.013). The SF-36 PCS, SF-36 MCS, and VAS were not significantly associated with shortening or greater trochanteric malunions.



Conclusion: Shortening following cephallomedullary nailing of IT fractures is associated with increased double stance time and decreased cadence. Similarly, increased shortening of the femoral neck and greater trochanteric malunion result in decreased HHS outcome scores in hip fracture patients.

See pages 401 - 442 for financial disclosure information.

Hip Fracture Patients on Non-Warfarin Anticoagulants: Is Surgical Delay Warranted?

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Purpose: The risk of bleeding in hip fracture patients on anticoagulants, particularly antiplatelet and factor Xa inhibitors, is not well defined. There is still controversy regarding whether operative delay is necessary in elderly hip fracture patients on these medications. The purpose of this study was to analyze surgical and clinical outcomes in hip fracture patients on anticoagulation, comparing those patients who were treated within 48 hours of admission with those whose surgery was delayed past 48 hours.

Methods: Patients with hip fractures treated operatively aged 55 and older at one academic medical center between October 2014 to September 2016 were analyzed. Patients on the following anticoagulants were included: antiplatelet drugs including clopidogrel and aspirin 325 mg, factor Xa inhibitors including rivaroxaban and apixaban, and the direct thrombin inhibitor dabigatran. Patient demographics including age, sex, and Charlson Comorbidity Index (CCI) were collected. Outcome measures included length of stay, transfusion rate, estimated surgical blood loss, procedure time, complication rate, and need for ICU/SDU (intensive care unit/step down unit) level care. Patients who underwent surgery within 48 hours of presentation were compared to those where surgery was delayed more than 48 hours. Outcomes were compared between groups using P value of <0.05 as significant.

Results: Of 551 hip fracture patients, 78 (14.3%) of these were on the anticoagulant medications included in this study. Of these 78 patients, 58 (74.4%) had surgery within 48 hours and 20 (25.6%) had surgery after 48 hours. When comparing the early and delayed fixation cohort, there was no difference in transfusion requirement (1.1 units vs 1.5 units, $P = 0.453$), length of surgery (73.0 minutes vs 74.8 minutes, $P = 0.806$), or blood loss (163.2 mL vs 170.0 mL, $P = 0.727$). Type of anticoagulant made no difference in transfusion requirement, blood loss, or length of surgery. There was also no difference in average number of complications developed or in need for ICU/SDU level care in the early fixation group and delayed fixation group.

Conclusion: In this study, patients on antiplatelet therapy, factor Xa inhibitors, or direct thrombin inhibitors who underwent surgical fixation of their hip fracture within 48 hours of admission were at no higher risk for transfusion, increased surgical blood loss, or longer operative time. This suggests that if otherwise medically optimized for surgery, surgeons should not hesitate in operating on hip fracture patients on these anticoagulant medications within 48 hours.

Δ Factors Associated with Revision Surgery Following Internal Fixation of Hip Fractures

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Purpose: Femoral neck fractures are associated with high rates of revision surgery following management with internal fixation. Using data from a multicenter trial evaluating different methods of internal fixation in patients with femoral neck fractures, we investigated the association between key baseline and surgical factors and the need for additional surgery to promote healing, relieve pain, treat infection, or improve function over 24 months post surgery. Additionally, we investigated factors specifically associated with (1) hardware removal and (2) implant exchange from cancellous screws (CS) or sliding hip screws (SHS) to total hip arthroplasty (THA), hemiarthroplasty (HA), or another internal fixation device.

Methods: We identified 15 potential factors a priori from baseline data, fracture characteristics, and surgical data from the trial that may be associated with additional surgery to promote healing, relieve pain, treat infection, or improve function. We also identified 7 factors that may be associated with hardware removal and 14 with implant exchange. We used multivariable Cox regression analyses to investigate these associations.

Results: Factors associated with increased risk of additional surgery included: female sex, (hazard ratio [HR] 1.79, 95% confidence interval [CI] 1.25-2.50; P = 0.001), higher body mass index (for every 5-point increase) (HR 1.19, 95% CI 1.02-1.39; P = 0.027), displaced fracture (HR 2.16, 95% CI 1.44-3.23; P <0.001), unacceptable quality of implant placement (HR 2.70, 95% CI 1.59-4.55; P <0.001), smokers treated with CS compared to smokers treated with SHS (HR 2.94, 95% CI 1.35-6.25; P = 0.006), and a fracture configuration corresponding to a Pauwels Type III as compared to Type II (HR 2.13, 95% CI 1.28-3.57; P = 0.004).

Conclusion: Results of this study may inform future research by identifying high-risk patients who may benefit from novel interventions, alternative rehabilitation strategies, and adjuncts to care.

Δ OTA Grant

See pages 401 - 442 for financial disclosure information.

Short Versus Long InterTAN Fixation for Geriatric Intertrochanteric Hip Fractures: A Prospective, Multicentre Head-to-Head Comparison

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Purpose: The benefit of using a long intramedullary device for the treatment of geriatric intertrochanteric hip fractures is unknown. The InterTAN device (Smith & Nephew, Memphis TN) is offered in either short (180-200 mm) or long (260-460 mm) constructs and was designed to provide stable compression across primary intertrochanteric fracture fragments. The objective of our study was to determine whether short InterTANs are equivalent to long InterTANs in terms of functional and adverse outcomes for the treatment of geriatric intertrochanteric hip fractures.

Methods: 108 patients with OTA classification 31A-1 and 31A-2 intertrochanteric hip fractures were included in our study and prospectively followed at one of 4 Canadian Level-I trauma Centers. Primary outcomes included the Functional Independence Measure (FIM) and the Timed Up and Go (TUG). Secondary measures included blood loss, length of procedure, length of stay, and adverse events. Outcome parameters were captured preinjury through recall and at regular intervals postoperatively out to 12 months.

Results: Our study included 71 short InterTAN and 37 long InterTAN patients with 31A-1 and 31A-2 intertrochanteric hip fractures. Age, sex, body mass index, side, living status, and comorbidities were similar between the 2 groups. Mean operative time was significantly lower in the short InterTAN group (61 minutes) as compared to the long InterTAN group (71 minutes) ($P < 0.05$). Functionally, the TUG was significantly ($P < 0.05$) shorter in the long InterTAN group despite having similar FIM total scores at 1 year. Pre- and postoperative hemoglobin values and transfusion rates were similar for the 2 groups. Average length of stay was 16.2 days for the long InterTAN group and 19.9 days for the short InterTAN group ($P > 0.05$). There were 5 periprosthetic femur fractures in the short InterTAN group versus 1 in the long InterTAN group. Nonmechanical adverse complications had similar incidence rates between the 2 InterTAN groups.

Conclusion: Short and long InterTAN patients displayed similar improvements in function following hip fracture fixation over a 12-month period. Operative times for short InterTAN fixation were significantly shorter than long InterTAN patients. A significantly higher proportion of short InterTAN patients sustained periprosthetic femur fractures within a year of implantation as compared to the long InterTAN group.

Fixation Failure and Time to Reoperation After Internal Fixation of Young Femoral Neck Fractures: A Population-Based Study

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Purpose: Non-geriatric patients with femoral neck fractures treated with internal fixation frequently experience reoperations for painful hardware, osteonecrosis, and nonunion. Conversion to total hip arthroplasty (THA) is a definitive marker of failed joint preservation and the need for salvage surgery. The primary aim of this study was to determine the reoperation rate and time to reoperation following internal fixation of young femoral neck fractures.

Methods: This study used linked provincial health databases to create a retrospective cohort of all British Columbia residents between the ages of 18 and 50 years who underwent internal fixation for a femoral neck fracture during 1997-2013. Patients with concomitant pelvis or acetabular fractures were excluded. A Kaplan-Meier analysis was performed to estimate the rate of failure of the index procedure for any reoperation and for THA specifically. A Cox proportional-hazards regression model was used to study the dependency of time to reoperation on sex and age.

Results: 796 young femoral neck fracture patients were treated with internal fixation during the study period. The patient population was primarily male (60.8%) with a median age of 43 years at time of injury (interquartile range [IQR]: 35-48). 235 (29.5%) experienced at least 1 reoperation at a median of 15.7 months (IQR: 7.6-30.6) from the index surgery. The majority of reoperations were for hardware removal (n = 192, 54.7%), followed by conversion to THA (n = 102, 29.1%). The median time to THA was 26.8 months (IQR: 11.5-50.4) from the initial fracture. Neither sex (hazard ratio [HR]: 1.13, 95% confidence interval [CI]: 0.88-1.48, P = 0.33) nor age (HR: 0.84, 95% CI: 0.64-1.09, P = 0.18) had a significant effect on time to reoperation.

Conclusion: 10% of young femoral neck fracture patients treated with internal fixation required conversion to THA within 5 years from their injury. When including other fracture-related indications for reoperations, 30% of these patients underwent at least 1 reoperation. These results highlight the common need for reoperation after a young femoral neck fracture and patients must be counseled accordingly. Given these failure rates, patients and surgeons may wish to consider primary arthroplasty for patients nearing 50 years of age.

See pages 401 - 442 for financial disclosure information.

Open Reduction is Associated with Greater Propensity-Stratified Hazard of Reoperation After Internal Fixation of Femoral Neck Fractures in Adults 18-65 Years of Age

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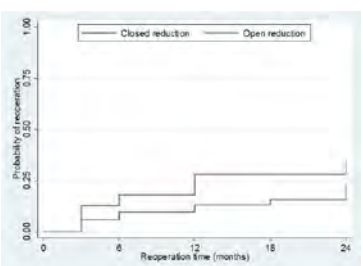
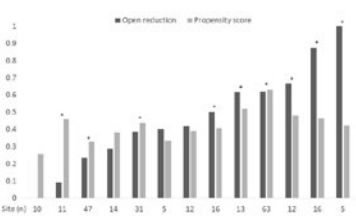
Purpose: The purpose of this study was to explore the association of open versus closed reduction technique with complications and reoperation after internal fixation displaced femoral neck fractures in young adults, adjusting for patient and injury factors associated with the choice to perform an open reduction.

Method: Retrospective review, 13 Level 1 trauma centers. Inclusion: patients 18-65 years with OTA Type 31-B2/B3 displaced femoral neck fractures treated with internal fixation with minimum 2-year follow-up or reoperation. Exclusion: pathologic fracture, associated femoral head or shaft fractures, and primary arthroplasty. A propensity score for treatment (open versus closed reduction) was calculated by stepwise logistic regression of covariates associated with treatment selected from an a priori set of demographic, comorbidity, radiographic, and surgical potential confounding variables. A Cox proportional hazard model of reoperation-free survival stratified on quintiles of the propensity score was regressed on treatment to obtain a pooled adjusted hazard ratio for reoperation.

Results: Of 255 patients with median 1.5 year follow-up, 117 (46%) underwent open reduction. The estimated propensity score was based on age, sex, injection drug use, osteoporosis, OTA classification, posterior fracture comminution, application of preoperative skin or skeletal traction, and surgery delay. Rates of open reduction varied markedly between centers, after controlling for case mix. 39 (33%) versus 30 (22%) reoperations occurred after open versus closed reduction ($p = 0.038$). Femoral head arthroplasty accounted for 42% of reoperations. Open reduction was associated with a significantly greater propensity-adjusted hazard ratio of reoperation of 2.40 (95% CI 1.36-4.23, $p = 0.003$).

Conclusion: Open reduction versus closed reduction of displaced femoral neck fractures in adults 18-65 years is associated with a significantly greater propensity-adjusted hazard of reoperation within 2 years. Prospective randomized clinical trials are indicated to confirm a causative effect of open versus closed reduction on reoperation after femoral neck fracture in this population.





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.

Femoral Neck Stress Fractures: Clinical Course and MRI Risk Factors for Progression

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Purpose: Femoral neck stress fractures (FNSFs) are an uncommon overuse injury usually seen in military recruits and endurance athletes with potentially devastating consequences if not diagnosed and treated at an early stage. MRI has been established as the most sensitive study for diagnosis and surgical indications have been recommended based on MRI features. The goal of this study is to retrospectively review the clinical course of FNSFs using an MRI-based protocol. We sought to identify any radiographic or clinical risk factors for disease progression leading to operative management.

Methods: We identified all MRI scans used for FNSF screening from 2002 to 2015. Inclusion criteria included all nondisplaced FNSFs. Demographic data, radiographic data, symptom duration, fracture progression, surgical intervention, return to run time, and return to duty rate and time were recorded. Each MRI scan was evaluated for edema, fracture lines percentage, and hip effusion. Surgical indications were a compression-sided stress fracture involving >50% of the neck width or progression on serial MRI.

Results: 798 MRI scans were performed to screen for FNSF and 327 stress fractures were diagnosed meeting inclusion criteria. No patients sustained a displaced fracture after being diagnosed with an FNSF. Initial MRI showed edema with fracture line in 72% and isolated edema in 28%. The fracture line involved an average of 25% of the femoral neck width. 49 patients (15%) were indicated for surgery based on the first MRI. Interval MRI was performed in 73% of patients at an average of 6 weeks. No progression was seen in any patient whose initial MRI showed focal edema without fracture line (25%). There was progression of fracture requiring surgery in 27 remaining patients (9.7%). Those who had a hip effusion on initial MRI had 20 times (relative risk [RR] 20.3; 95% confidence interval [CI], 7.4-56.0; P <0.0001) the risk of progression to surgical fixation compared to those without a hip effusion.

Conclusion: The majority of FNSFs can be managed with strict weight-bearing restrictions and a gradual return to activity without risk of completion and displacement. There is a cohort of patients with minimal edema and no fracture line on the initial MRI who have reliable improvement with nonoperative treatment. Approximately 10% of patients with fracture lines will have progression of the fracture requiring surgical fixation. The presence of an effusion on the first MRI is strongly predictive of progression.

See pages 401 - 442 for financial disclosure information.

Treatment of Femoral Neck Fractures in Patients 45 to 64 Years of Age

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Purpose: Femoral neck fractures are challenging problems for treating surgeons and often cause prolonged disability for patients who sustain them. Young patients with femoral neck fractures are optimally treated with anatomic reduction and stable fixation, while patients over the age of 65 are often treated with arthroplasty. However, little data exist regarding the treatment of these fractures in patients between the ages of 45 and 64 years. This epidemiologic study was designed to analyze the in-hospital outcomes associated with hip arthroplasty and internal fixation for treatment of femoral neck fractures in patients aged 45 to 64 years.

Methods: The Nationwide Inpatient Sample (NIS) database was utilized to access US inpatient data from 2000 to 2012. Patients between the ages of 45 and 64 years who sustained femoral neck fractures were included based on ICD-9 coding data. Total annual case numbers were estimated by the Healthcare Cost and Utilization Project (HCUP) online query system. Examined variables were age, sex, and Charlson Comorbidity Index (CCI). Multivariable linear regression was used to determine variables associated with mortality and in-hospital complications. Standard error was calculated for all variables. Odds ratios and 95% confidence limits were calculated for logistic regression variables. Statistical significance was set at $P < 0.05$ a priori.

Results: From 2000 to 2012 total hip arthroplasty (THA) use increased from 267 in 2000 (5.3% of operatively managed fractures) to 1005 (17.5% of operatively managed fractures) in 2012 ($P < 0.0001$). Over the 13-year study period, the percentage of femoral neck fractures occurring in our study group, ages 45 to 64 years, increased significantly from 7.43% to 10.7% ($P < 0.0001$). Patients undergoing THA had an average hospital cost of $67,146 while patients undergoing internal fixation had an average hospital cost of $41,845 ($P < 0.0001$). The average length of stay for patients undergoing THA was 6.9 days, while the average length of stay for patients undergoing internal fixation was 5.6 days ($P < 0.0001$). The in-hospital complication rate for THA was 14.1%, while the average in-hospital complication rate for internal fixation was 8.0% ($P < 0.0001$).

Conclusion: This study demonstrates that the use of THA in treatment of femoral neck fractures in patients aged 45 to 64 years increased 3.2-fold over the 13-year study period. This treatment is associated with increased hospital cost, length of stay, and complications. Additionally, the percentage of total femoral neck fractures occurring in this age group is steadily increasing over time.

Is Distal Locking Necessary in Long Cephalomedullary Nailing of Intertrochanteric Fractures?

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Purpose: Intramedullary nailing has become the treatment of choice for intertrochanteric (IT) fractures. Some surgeons have proposed that with the use of long nails, distal locking is not required. The purpose of this study is to compare the complication rates in a series of long cephalomedullary nails for the treatment of IT fractures with and without distal locking.

Methods: A single-surgeon series of patients were treated prospectively entered into a database. All patients were treated with an Intertan long cephalomedullary nail. Demographic data, fracture type, and complications were prospectively entered. Patients with subtrochanteric and reverse obliquity fractures (A3) were excluded. All fractures were treated with a double integrated screw into the femoral head. During the first half of the study distal locking screws were not used and in the later part of the study, all nails were locked distally. Complications were categorized as major (neck axis shortening ≥10 mm, axial shortening ≥10 mm, return to the operating room [OR], clinical malrotation, distal nail perforation, or distal fracture) and minor (neck axis shortening of 5-10 mm, broken distal screw with <10 mm axial shortening, distal abutment without need for change in treatment).

Results: We prospectively evaluated 341 patients; mean age 84 years with average follow-up 436 days. There were 27 2-part, 75 3-part, and 239 4-part fractures. There were 68 complications (42 major and 26 minor). Complications were more common in the unlocked group (27% vs 14%). Most important, major complications were more common in the unlocked group (21% vs 5%). Unplanned return to the OR was 3 times more common in the unlocked cohort but did not reach statistical significance. Basicervical type fractures had the highest complication rate for both cohorts (25% locked and 39% unlocked group).

Conclusion: We evaluated the complications of patients with intertrochanteric fractures treated with the same brand of long nail with and without distal locking screws. The complication rate was significantly different and 2 times higher and the major complication rate was 4 times higher in the unlocked cohort despite having more 4-part fractures in the locked group. We conclude that when treating intertrochanteric hip fractures with a long nail, distally locking will decrease the overall and major complication rates and we recommend their routine use.

See pages 401 - 442 for financial disclosure information.

Early Comparative Outcomes of Continuous Carbon Fiber-Reinforced Polymer Plate in Fixation of Distal Femur Fractures

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Purpose: Distal femur fractures are most commonly been treated with stainless steel (SS) or titanium lateral locked plating. Fixation in this method has a nonunion rate of 6%-20%. Certain construct properties may optimize healing potential, but no one fixation approach has been shown to produce more reliable union. Carbon fiber-reinforced polyetheretherketone (CFR-PEEK) plates are an alternative fixation with a higher fatigue strength to SS implants and modulus of elasticity close to cortical bone. No published studies have evaluated the use of modern CFR-PEEK plates to treat distal femur fractures. This study reports on our early results.

Methods: A single surgeon cohort of patients with distal femur fractures was reviewed between December 2011 and December 2016. The surgeon transitioned from using a variable-angle, SS distal femoral locking plate to a CFR-PEEK distal femoral plate during the study interval allowing for a comparison. Time to full weight bearing, time to union, hardware failure, and reoperation were assessed.

Results: 38 patients were compared (24 SS, 14 CFR-PEEK). The average age was 54 years (range, 18-89) and 68 years (33-86) in the SS and CFR-PEEK groups, respectively (P = 0.017). There were no significant differences in smoking status and corticosteroid use between groups. The CFR-PEEK group contained significantly more patients with diabetes (57 vs 13%, P = 0.003) and peripheral vascular disease (43 vs 0%, P = 0.018). Fractures were classified according to the OTA Compendium with 19 A-type (15 periprosthetic) and 20 C-type fractures. Open injuries were more common in the SS group (21 vs 50%, P = 0.049). The average follow-ups were similar, 48 weeks (range, 10-122) in the SS group and 39 weeks (10-60) in the CFR-PEEK group. Hardware failures were seen in 8% of the SS group compared to 0% in the CFR-PEEK group (P = 0.27). Time to full weight bearing (mean 11 weeks) and time to union (mean 14 weeks) were similar (P = 0.11, 0.71, respectively). Nonunion was diagnosed in 25% patients in the SS group and 0% patients in the CFR-PEEK group (P = 0.04). There were no reoperations in the CFR-PEEK group.

Conclusion: CFR-PEEK plates showed similar time to radiographic union and full weight bearing as SS plates with no hardware failures, reoperations, or nonunions in short-term follow-up. These data suggest that CFR-PEEK plates may be a viable alternative to SS plates in fixation of these fractures. Further study is needed to assess for longer-term complications and functional outcomes.

New versus Old: A Prospective, Randomized Controlled Trial Comparing the 95° Angled Blade Plate with the Locking Condylar Plate for Distal Femur Fractures

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Purpose: The purpose was to determine if new technology, the locking condylar plate (LCP), was better than old technology, the 95° angled blade plate (ABP). Our hypothesis was that LCP would be superior to ABP.

Methods: The investigators performed a randomized trial comparing ABP and a distal femoral locking plate (LCP) from 2007 to 2015. Coronal plane fractures (n = 42) or insufficient cortex for blade insertion (n = 3) were excluded. Type 3C open fractures (n = 3), periprosthetic fractures (n = 51), proximal femur fractures (n = 3), and preexisting implants (n = 3) were excluded, leaving 139 patients with 142 fractures. Of those, 2 declined, 1 was deemed ineligible due to mental illness, and 60 fractures were excluded by surgeon preference, so 78 patients with 79 eligible fractures were randomized (36 ABP, 42 LCP). No differences in demographics or injury features were noted between randomized and nonrandomized eligible patients. Outcomes included nonunion, minor deformity (≥5°), majority deformity (≥10°), infection, and secondary procedures.

Results: 31 males and 47 females with mean age 60 years and mean ISS 16 with 62 closed and 17 open fractures (5 type 1 and 12 type 3A), classified as 33A (n = 38) and 33C (n = 41) were studied. 73 fractures occurred after blunt trauma (27 motorized collisions, 5 falls from height, 41 falls from standing), and 6 were after low-energy gunshot. ABP and LCP patients were similar for age, mechanism, associated injuries, and patterns. All patients were followed to union with mean follow-up 25 months (range, 12-40). There were 2 infections, 1 superficial after LCP and 1 deep after ABP. There were 3 nonunions after LCP, none after ABP (P = 0.06). Nine patients healed with minor deformity (≥5°) after LCP versus 5 after ABP. One fracture in the ABP group united with a major deformity (≥10°) versus 2 after LCP. There were 7 patients who underwent secondary procedures after LCP versus 2 patients after ABP (P = 0.08).

Conclusion: The investigation failed to support the hypothesis of newer being better. There was no evidence to indicate the LCP was superior to the ABP and while trends suggested that the ABP had better rate of primary union (P = 0.06) and fewer secondary procedures than the LCP (P = 0.08). In an era of increasing measurement of quality and cost, the ABP represents a value proposition.

See pages 401 - 442 for financial disclosure information.

A Prospective Randomized Control Trial Comparing Immediate Weight Bearing Versus Touch-Down Weight Bearing in Extra-Articular Distal Femur Fractures

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Purpose: Distal femur fractures can be difficult to manage. Locked lateral plates have become a standard of care for these challenging fractures. The tendency has been to protect weight bearing postoperatively in this often elderly population. The purpose of this study was to prospectively randomize patients regarding postoperative weight bearing status, distributed to either weight bearing as tolerated (WBAT) versus touch-down weight bearing (TDWB). Our hypothesis is that patients allowed WBAT immediately would have similar rates of early catastrophic failure and union compared to the TDWB group.

Methods: This prospective randomized cohort study evaluated the outcomes of patients with distal femur fractures (OTA 33-A) treated with open reduction and internal fixation (ORIF) via locked lateral plating. These patients were randomized to either immediate WBAT versus TDWB for 12 weeks. The attending surgeon was blinded to the weight-bearing status of the patient until postoperatively. From April 2015 to January 2017, 31 patients from a Level I trauma center met inclusion criteria, with 23 having fractures adjacent to a total knee arthroplasty. Primary outcomes include fracture union, mortality, and early catastrophic failure, defined as any bent or broken hardware or loss of reduction within the first 3 months postoperatively. The patients were examined at routine clinic intervals with radiographs.

Results: Of the 31 patients, 16 were randomized to the TDWB group and 15 to the WBAT group. One patient in the TDWB group had a nonunion requiring revision ORIF. One patient in the WBAT group had loss of reduction requiring conversion to a distal femoral replacement. Fracture union was achieved in 11 patients, 5 in the WBAT group and 6 in the TDWB group. Five patients in each group had progression of radiographic healing but incomplete union at their last follow-up. Four patients died within 6 months postoperatively (13%). Three patients have been lost to follow-up.

Conclusion: Early mobilization after orthopaedic surgery is vital to achieving an optimal outcome and preventing postoperative complications. Traditional management of distal femur fractures has involved protected weight bearing postoperatively. Despite the small cohort, this prospectively randomized study demonstrates the low likelihood of early catastrophic failure when allowing patients to weight-bear immediately after surgery. This study also confirms the high mortality rate associated with distal femur fractures in the elderly population.

Radiographic Healing of Far Cortical Locking Constructs in Distal Femur Fractures: A Comparative Study with Standard Locking Plates

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Purpose: Distal femur fractures are commonly treated with locking plate fixation. These fractures are often comminuted and depend on some degree of interfragmentary motion to stimulate union. Far cortical locking (FCL) screw constructs are designed to permit increased controlled interfragmentary motion, which has been shown in animal models to increase callus formation to a greater extent than standard locking plate (LP). Despite the use of screws, actual clinical and radiographic data on the effectiveness has been limited. The purpose of this study is to investigate radiographic callus formation as a primary outcome of FCL compared with LP constructs, using the modified RUST (Radiographic Union Score for Tibial Fractures) score. Our hypothesis is that FCL constructs have increased callus formation as compared to standard LP constructs.

Methods: A cohort of 146 distal femur fractures were identified retrospectively from 2011-2016. After excluding AO/OTA Type B fractures, nonunion cases, and less than 16 years old), 96 patients were included for analysis. AP and lateral knee/ femur radiographs were reviewed using the modified RUST score to evaluate callus formation of each cortex of the distal femur at 6, 12, 24 weeks, and final follow-up when available. Radiographs for patients with plate fixation were blinded to the type of screws. There were 52 patients in the FCL group and 44 in the LP group.

Results: There were no significant differences between FCL and LP constructs in terms of demographic data, or rates of complications. The results of summation of modified RUST scores from 3 investigators were 21.1 and 18.3 ($P = 0.02$), 29.9 and 27.2 ($P = 0.03$), 34.0 and 33.4 ($P = 0.8$), and 40.3 and 39.0 ($P = 0.58$) at 6, 12, 24 weeks and final follow-up, respectively. No significant differences were noted between groups for fixation failures, or nonunion rates. Union rate was 90%, 92%, and 88% for all patients, FCL and LP, respectively, at final follow-up. There was no difference in overall complications, infection, or revision rate between FCL and LP constructs.

Conclusion: To our knowledge, this is the first comparative study between FCL and LP constructs. In this study the FCL group was noted to have significantly higher modified RUST scores at the 6 and 12-week time period. Further prospective study designs should be directed at helping to clarify the role of interfragmentary motion on callus formation in distal femur fractures.

See pages 401 - 442 for financial disclosure information.

Δ Progenitor Cell Therapy to Improve Fracture Healing in a Diabetic Rat Critical Size Defect Model

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Purpose: The purpose of this study was to examine the effect of endothelial progenitor cells (EPCs) isolated from healthy and diabetic animals on bone healing in healthy and diabetic recipients. We hypothesized that local EPC therapy would effectively promote bone healing in all recipient animals, though EPCs from healthy donors would be the most effective.

Methods: Diabetes was induced in rats via streptozotocin. EPCs were isolated from the bone marrow of healthy and diabetic animals and expanded in culture for 7 days. A 5-mm segmental bone defect was surgically created in the right femur and stabilized. Gel foam scaffolds seeded with cells or medium alone were implanted in the defect, creating 6 study groups (Table 1). Radiographs were taken biweekly until animal sacrifice at 10 weeks. Radiographs were scored for the presence of union and extent of healing by 2 blinded orthopaedic surgeons.

Results: Treatment with EPCs resulted in significantly higher radiographic scores than diabetic controls, irrespective of a healthy or diabetic state (Fig. 1A). Although not statistically significant, lower scores were observed in diabetic animals receiving cells compared to healthy animals receiving cells. Representative radiographs are shown in Figure 1B.

Conclusion: Our preliminary results suggest that EPCs can promote bone healing in a model of diabetic fracture healing. However, the rate of union and extent of bony healing on radiographs were increased in healthy animals versus diabetic animals, irrespective of the cell source. Thus the diabetic versus healthy state of the host appears to be more critical to fracture healing than whether the EPCs are derived from a diabetic or healthy source.

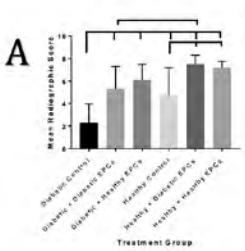

Table 1: Study Treatment Groups

Recipient Animal Type	Treatment Received
Healthy	1) Healthy EPCs (1 million) 2) Diabetic EPCs (1 million) 3) Control (Medium alone)
Diabetic	4) Healthy EPCs (1million) 5) Diabetic EPCs (1 million) 6) Control (Medium alone)

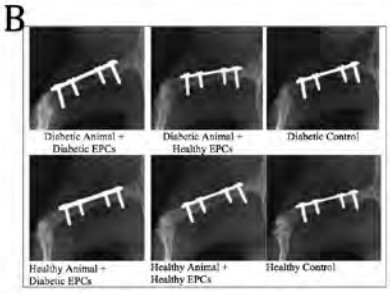

Figure 1. (A) Graphical representation of radiographic scores (* = p values <0.05) and (B) representative radiographic images from all 6 treatment groups

Δ OTA Grant

Evaluation of Vertically Oriented Femoral Neck Fracture Fixation in a Clinically Relevant Biomechanical Model

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Purpose: Surgical fixation of vertically oriented femoral neck fractures continues to be associated with high rates of fixation failure. Recent literature has further defined the true morphology of these fractures, specifically axial plane obliquity and the presence of posterior-inferior comminution. The purpose of this study was to evaluate the effect of these features using commonly implemented fixation strategies. We hypothesized that axial obliquity and posterior comminution would decrease the structural integrity of both fixation constructs.

Methods: Biomechanical testing was performed on 4 vertical femoral neck fracture models: (1) 90° coronal plane fracture, (2) 90° coronal plane fracture with -24° of axial obliquity, (3) 90° coronal plane fracture with posterior-inferior comminution, and (4) 90° coronal plane fracture with -24° of axial obliquity and posterior-inferior comminution. In each group (n = 10), 5 specimens were fixed with 3 cannulated screws in an inverted triangle arrangement (CS) and 5 were fixed with a sliding hip screw (SHS) with supplemental anti-rotation screw. Load to failure through a custom jig that provided an axial preload and torsional loading was performed. Torque at failure and angular displacement were recorded.

Results: The pure coronal plane osteotomy demonstrated the greatest torque before failure and resistance to displacement with load, regardless of fixation construct ($P < 0.03$). All models failed at a significantly greater torque after fixation using 3 cannulated screws versus an SHS with anti-rotation screw ($P < 0.02$). While axial fracture obliquity alone resulted in increasing fracture instability, once posterior comminution was introduced, axial obliquity was not a contributing factor to stability.

Conclusion: Axial fracture obliquity and the presence of posterior comminution had a significant effect on construct stability after fracture reconstruction; this was observed in both the SHS and CS fixation groups. While axial fracture obliquity increased instability, the addition of posterior comminution negated this effect. In our model, the CS group performed significantly better than the SHS group in all measurements. This study represents the first creation of a model that accurately represents in vivo fracture morphology and demonstrates the contribution of axial fracture obliquity and posterior comminution on fixation strength.

See pages 401 - 442 for financial disclosure information.

Δ Stay Cool: Evaluation of External Fixation Pin Temperature Within the MRI Bore

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Purpose: The purpose of the study is to: (1) report the thermal changes encountered at the pin/skin interface in a cadaver with a knee-spanning external fixator inside the MRI bore and (2) report on the quality of the MRI sequences collected in the same model.

Methods: Three external fixation systems were placed on 2 cadaveric limbs in an identical knee-spanning configuration. Fiberoptic thermal probes were placed at the pin/skin interface of a femoral and tibial pin. A control probe was embedded in the proximal soft tissues of the thigh. The 6 limbs then underwent MRI knee scans using a 1.5-T magnet. Real-time thermal data were collected with fiberoptic temperature sensors. A Pearson correlation coefficient was performed on the tibial and femoral pins versus the control with R2 representing an estimate of the effect of the control temperature on the pins. A value of $P < 0.05$ indicates no significant change from the control. Two radiologists blinded to the fixator evaluated the images for image quality using a standardized 5-point grading scale ranging from Grade 1, representing severe artifact affecting the entire image, to Grade 5, representing no artifact.

Results: The control temperature on all limbs increased during the scan as the limb temperatures neutralized to the surrounding air (19-22°C). On average across all systems studied, the femoral pins were 1.31°C cooler than the control probes (range, -0.04 to 3.04) and the tibial pins were 1.87°C warmer than the control probes (range, -1.64 to -2.32). There was a significant correlation between the temperatures of the control probe and the temperatures of both the femoral and tibial pins for all frames ($P < 0.001$). This implies that the temperature changes of the femoral and tibial pins were the similar to the control with no independent effect from the MRI magnet. The average quality of the images of the knee was rated at 4.58 (range, 4.33-4.67), meaning there was minimal to no artifact affecting image interpretation.

Conclusion: Clinically inconsequential thermal changes that did not differ from the control were detected at the pin/skin interface throughout the entire scan for each of the external fixation models. The overall image quality and interpretability of the images collected were excellent for each model.

Δ OTA Grant

Δ Delayed Endothelial Progenitor Cell Therapy Promotes Bone Defect Repair in a Clinically Relevant Rat Model

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Purpose: The repair of nonunion and the restoration of bone loss secondary to trauma remains a challenge for orthopaedic surgeons. Recent experimentation in animal models has suggested that endothelial progenitor cells (EPCs) are capable of enhancing bone defect repair when applied acutely to surgically created defects. However, in the clinical context of open fractures complicated by bone loss, or in the nonunion setting, bone grafting is commonly delayed to minimize graft resorption, reduce infection risk, and allow soft-tissue healing. To date, animal models investigating EPC therapy have failed to replicate this environment. The current study sought to address this by investigating EPC therapy in a clinically relevant model of delayed treatment.

Methods: 5-mm segmental defects were surgically created in the right femur of male Fischer 344 inbred rats. Defects were stabilized with mini-plate and screws, and left empty for 3 weeks. After 3-week delay (delayed group), rats were randomized to a second surgery and treatment with either 1 million EPCs on a gel foam scaffold (n = 8) or gel foam scaffold alone (n = 8). A second group of rats (acute group) underwent the same femur fracture surgery, and were treated acutely with either 1 million EPCs on a gel foam scaffold (n = 6) or gel foam scaffold alone (n = 6). EPCs were isolated from the bone marrow of Fischer 344 rats, and subsequently expanded in culture for 7-8 days prior to transplantation. Animals were sacrificed at 10 weeks post-treatment, and defect healing was analyzed by plain radiographic assessment, microCT analysis, and biomechanical testing.

Results: Animals treated with EPCs in acute or delayed fashion achieved 100% union rate, whereas defects treated with cell-free scaffolds were united in 0% of acute controls and 37.5% of delayed controls. Furthermore, acute and delayed treatment with EPCs improved trabecular number and trabecular spacing compared to the respective control groups. Lastly, defects treated with EPCs in either acute or delayed fashion sustained higher ultimate torque compared to the respective controls.

Conclusion: Results from this study indicate that EPCs are capable of enhancing bone repair when applied to bone defects in acute or delayed fashion. Importantly, no differences in outcomes were observed between acute and delayed treatment with EPCs. These data suggest that EPC-based therapy could represent a substantial advance for the treatment of nonunions and traumatic bone defects in humans, and further research aimed at bringing this therapy to the clinical realm is warranted.

Δ OTA Grant

See pages 401 - 442 for financial disclosure information.

Allgöwer-Donati Versus Vertical Mattress Suture Technique Impact on Perfusion in Ankle Fracture Surgery: A Randomized Clinical Trial Using Intraoperative Angiography

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Purpose: The purpose of this study was to evaluate which primary wound closure technique for ankle fractures affords the most robust perfusion as measured by laser-assisted indocyanine green angiography (LA-ICGA): Allgöwer-Donati or vertical mattress.

Methods: This prospective, randomized study was conducted at a Level I academic trauma center. 30 patients undergoing open reduction and internal fixation (ORIF) for ankle fractures were prospectively randomized to Allgöwer-Donati (n = 15) or vertical mattress (n = 15) closure. Demographics were similar for both cohorts with respect to age, sex, body mass index, surgical timing and AO/OTA fracture classification. The main outcome measurement was skin perfusion, quantified in fluorescence units with LA-ICGA along the lateral incision as well as anterior and posterior to the incision at 30 separate locations. Minimum follow-up was 3 months (mean 4.7 months).

Results: Allgöwer-Donati enabled superior perfusion compared to the vertical mattress suture technique. Mean incision perfusion for Allgöwer-Donati was 51 (SD = 13) and for vertical mattress was 28 (SD = 10; P <0.0001). Mean perfusion impairment was less in the Allgöwer-Donati cohort (12.8, SD = 9) compared to the vertical mattress cohort (23.4, SD = 14; P = 0.03). One patient in each cohort experienced a wound complication.

Conclusion: The Allgöwer-Donati suture technique offers improved incision perfusion compared to vertical mattress closure following ORIF of ankle fractures. Theoretically this may enhance soft-tissue healing and decrease the risk of wound complications. Surgeons may take this into consideration when deciding closure techniques for ankle fractures.

Procedural Sedation Compared to Intra-articular Block for Closed Reduction of Ankle Fractures

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Purpose: Our objective was to compare the safety of procedural sedation to intra-articular block, evaluate efficiency and efficacy for each method, and determine effects of physician specialty on these outcomes.

Methods: An initial retrospective EMR (electronic medical record) chart review utilizing CPT codes consistent with ankle fracture requiring manipulation was performed for patients seen in an Emergency Department (ED) of a Level I trauma center from 2005-2016. The primary outcome was rate of successful reduction. Several secondary outcome measures were defined: reduction attempts, time until successful reduction, time spent in the ED, rate of hospital admission, and adverse events. Continuous outcome measures were compared using a 2-sample t test if the data followed a normal distribution; otherwise a nonparametric (Mann-Whitney) test was used to compare such differences. Categorical outcome measures were compared utilizing chi-square tests.

Results: After exclusion criteria were applied, our study included 114 patients who underwent procedural sedation and 221 patients who received an intra-articular block. There was no significant difference in age, gender, body mass index, or American Society of Anesthesiologists (ASA) score between patients receiving either form of analgesia. 64% of patients receiving procedural sedation sustained a fracture dislocation compared to 33% of patients receiving intra-articular block ($P < 0.001$). Rate of successful reduction, number of reduction attempts, time spent in the ED, and rate of hospital admission was equivalent between both groups. One patient required intubation after procedural sedation (0.9%). Orthopaedic surgeons achieved higher rates of successful reduction in one attempt compared to ED providers ($P > 0.007$).

Conclusion: Both intra-articular block and procedural sedation are excellent options for analgesia that result in high rates of successful closed reduction of ankle fractures with adequate safety.

See pages 401 - 442 for financial disclosure information.

Effect of CAM Boot Immobilization on Weight-Bearing Stability in Syndesmotic Injuries: A Cadaveric Study

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Purpose: Ankle injuries are one of the most frequent traumas of the lower limb. The syndesmosis is also affected in up to 18% of cases. The degree of instability of syndesmotic joint depends on which ligaments are affected. The syndesmotic complex is composed of the anterior inferior tibiofibular ligament (AiTFL), the posterior inferior tibiofibular ligament (PiTFL), and the interosseous ligament (IOL), which all play various roles in maintaining tibiofibular joint congruity. Radiographic widening of the syndesmosis is not evident when facing an incomplete injury. The primary goal of our study was to evaluate the effect of simulated weight bearing on syndesmotic instability resulting from isolated AiTFL injury and from combined AiTFL/IOL injuries. The secondary goal was to evaluate the effect of a controlled ankle motion (CAM) walking boot on syndesmosis stability following injury. We hypothesized that the CAM boot would prevent significant instability even in 2- ligament injuries.

Methods: Ten ankle cadaveric specimens were dissected to create progressive iatrogenic syndesmosis ruptures. Uninjured syndesmoses were compared to isolated AiTFL and combined AiTFL/IOL ruptures. The specimens were fitted in a custom-made device to allow stabilization of the leg and apply a reproducible axial load (AL) of 750N. For each specimen and injury pattern, CT images were obtained. Distal tibiofibular relationship was evaluated using a previously validated measurement system developed on CT. Wilcoxon tests for paired samples and nonparametric data were done to compare the different conditions.

Results: When comparing ankles with isolated AiTFL to combined AiTFL/IOL rupture with and without AL, the only significant difference was an increase in internal rotation between the incisura and a line drawn in the axis of the fibula. It appears that axial loading does not impact syndesmotic stability. With the CAM orthopaedic boot, no significant widening of the syndesmosis happened when either one or both ligaments were sectioned, in an axial loading state. We therefore confirmed our hypothesis that even with 2 syndesmotic ligament injuries, axial loading in a CAM boot does not affect distal tibiofibular anatomy.

Conclusion: This study reveals that weight bearing without rotational force does not affect the stability of the syndesmosis. Incomplete syndesmotic injuries can likely be treated with nonoperative treatment in a CAM boot and weight bearing as tolerated. Further clinical studies are needed to confirm these findings.

Treatment of Low-Energy Lisfranc Joint Injuries in a Young Athletic Population: Primary Arthrodesis Compared with Open Reduction and Internal Fixation

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Purpose: Primary arthrodesis (PA) has been shown to have comparable or better outcomes than open reduction and internal fixation (ORIF) in high-energy Lisfranc injuries. There is a lack of comparable data investigating injuries associated with low-energy mechanisms. The objective of this study was to retrospectively compare primary arthrodesis with ORIF of low-energy Lisfranc injuries in a young athletic population.

Methods: All surgically managed low-energy (sustained during athletic activity, ground level twisting, or fall from less than 3 feet) Lisfranc injuries were identified at a single military tertiary referral center from July 2010 to June 2015. The injury pattern, time to diagnosis, and method of treatment were reviewed. Complication rates, secondary procedures, military fitness test scores, return to full military activity (defined as the ability to perform their primary job functions and participate in mandatory athletic activity), and Foot and Ankle Ability Measure (FAAM) scores were compared.

Results: 32 patients were identified with the average age of 28 years. 69% were primarily ligamentous injuries and the lateral column was never involved. PA was performed in 14 patients with ORIF in 18. Minor complications occurred in 10 patients. Implant removal was performed in 15 (83%) in the ORIF group and 2 (14%) in the PA group ($P = 0.005$). Visual analog scale (VAS) pain at final evaluation averaged 1.6. 29 of 32 (91%) were able to return to full military activity. The PA group returned to full duty at an average of 4.5 months while the ORIF group returned at an average of 6.7 months ($P = 0.0066$). The PA group ran their fitness test an average of 9 seconds per mile slower than their preoperative average while the ORIF group ran it an average of 39 seconds slower per mile ($P = 0.032$). There were no differences between the 2 groups in the FAAM scores at an average of 35 months.

Conclusion: In this study, low-energy Lisfranc injuries treated with primary arthrodesis had a lower implant removal rate, an earlier return to full military activity, and better fitness test scores, but there was no difference in FAAM scores at an average of 35 months.

See pages 401 - 442 for financial disclosure information.

Cost-Benefit Analysis of Syndesmotic Screw Versus Suture-Button Fixation in Tibiofibular Syndesmotic Injuries

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Purpose: Although suture buttons have been shown to have a lower rate of reoperation than screws in syndesmosis repair, the cost of these implants is up to 40 times greater than that of screws. This study was undertaken to evaluate the cost-effectiveness of suture buttons in syndesmosis repair.

Methods: A decision-tree model was constructed to describe outcomes after syndesmosis repair using suture buttons and standard syndesmotic screws. Outcomes were uneventful healing, removal of symptomatic implants, infection requiring debridement, and persistent diastasis requiring revision. Weighted literature averages were used to estimate variables to define a baseline model. Outcomes were measured in quality-adjusted life years (QALYs). Procedure and implant costs were derived from Medicare reimbursement rates and the University Health System Consortium (UHC), respectively. An incremental cost-effectiveness ratio (ICER) threshold of $50,000 per QALY was used to evaluate cost-effectiveness. Sensitivity analysis was then performed on multiple variables to assess cost-effectiveness across a range of values.

Results: The baseline model did not show the use of suture buttons to be cost-effective at a price of $850 (the median price per the UHC). Holding all other variables fixed, the suture button became cost-effective at a price of $792. With a suture button price of $850, if the implant removal rate for syndesmotic screws is at least 8% greater than the removal rate of suture buttons, then a suture button would be more cost-effective. Hence, for the baseline removal rate for symptomatic suture buttons (5.9%), symptomatic screw removal rate must be less than 13.9% for screws to be cost-effective. Sensitivity analysis showed that the model is exquisitely sensitive to small perturbations in reoperation rates.

Conclusion: Moving away from the practice of routinely removing all syndesmotic screws has changed the financial landscape of syndesmosis repair considerably. Suture buttons are cost-effective alternatives to screws in patient populations or practices in which screw removal is expected to be above a certain calculable threshold. More specifically, at the median UHC cost, suture buttons are likely to be cost-effective over screws for symptomatic screw removal rates greater than 13.9%. Cost-effectiveness is notably sensitive to changes in implant removal rates and the number of devices used per patient. We strongly recommend that each surgeon perform their own analysis based on their patient outcomes and implant removal rates.

Functional Outcomes of Syndesmotic Injuries Based on Objective Reduction Accuracy at Minimum 1-Year Follow-up

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Purpose: Despite the perceived importance of anatomic syndesmotic reduction and fixation, malreduction rates (as detected by CT) are reported to be between 15% and 52%. A malreduction threshold of 1-2 mm has been used arbitrarily, yet it is unknown which malreduction characteristics can be tolerated and to what degree before a clinically significant change is noted. The purpose of this study was to objectively evaluate the relationship between specific syndesmotic reduction characteristics and clinical outcomes using validated patient-reported questionnaires.

Methods: A cohort of patients with unilateral operatively treated syndesmotic injuries were consented and prospectively enrolled. As part of a standardized postoperative protocol, patients underwent bilateral ankle CT scans to assess the syndesmotic reduction. Standardized measurements were taken using previously described protocols. 69 patients were enrolled. Nine were excluded perioperatively. Of the remaining 60 patients, 12 were lost to follow-up leaving 48 (80%) with a minimum 1-year follow-up. Olerud-Molander Ankle Score, Short Musculoskeletal Function Assessment, and Numeric Pain Rating Scales were collected at a minimum 1-year follow-up.

Results: There were measured malreductions of at least 2 mm or 10° in 31 patients. There were measured malreductions of at least 3 mm or 15° in 14 patients. There was a single patient with a linear malreduction of >4 mm (5.4 mm). There were no measured rotational malreductions >20°. We were unable to demonstrate significant differences in functional outcomes at 1-year follow-up based on measured malreductions for each measured malreduction threshold. For linear measurements at the 1.5-mm, 2-mm, and 3-mm malreduction threshold, and angles 1 and 2 at a 10° rotational malreduction threshold, there was no significant differences between reduced and malreduced groups in all outcome scores at 1-year follow-up. Medicaid patients reported significantly worse outcome scores when compared to those with private insurance, Medicare, and those completely uninsured.

Conclusion: In our cohort, we were unable to find clinically important patient-reported outcomes differences between reduced and malreduced groups with a threshold of 2 mm at 1-year follow-up.

See pages 401 - 442 for financial disclosure information.

Going Rogue with Perioperative Antibiotics in Ankle Fracture Surgery: Whom Are We Protecting?

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Purpose: Surgeon preference has been replaced in favor of an approach using evidence-based medicine for most things in orthopaedics. The use of perioperative antibiosis in ankle fracture surgery is standardized for inpatients (24 hours of antibiotics postoperatively) but variable for outpatient surgery. Most surgeons do not routinely prescribe antiobiotics postoperatively for patients undergoing outpatient ankle fracture surgery. Other surgeons prefer the use of a 24-hour oral antibiotic regimen for outpatient ankle fracture surgery. In this study, inpatients receiving 24 hours of intravenous antibiotics were compared to those patients receiving 24 hours of PO (per os [oral]) antibiotics and those receiving no postoperative antibiotics. The purpose of this study was to compare the efficacy of different methods of perioperative antibiosis in ankle fracture surgery.

Methods: 1442 patients with ankle fractures requiring open reduction and internal fixation were retrospectively reviewed in this multicenter study. Demographic data including age, sex, body mass index (BMI), and race were collected. Clinical data including diabetes status, smoking status, hepatitis C virus (HCV) or human immunodeficiency virus (HIV) status, draining wound, infection requiring additional antibiotics (abx), and infection requiring return to operating room (RTOR) were statistically compared across the groups.

Results: Complete results are provided in Table 1. These data suggest no differences in incidence of draining wound, cellulitis, or return to OR for infection between the 3 groups. No differences were noted between the groups for any risk factors for infection including BMI, previous infection, smoking status, HCV/HIV status, or diabetes.

Conclusion: The use of antibiotics postoperatively, whether intravenous or oral, did not decrease the incidence of clinically significant or clinically insignificant postoperative infection. Based on the findings in this study, there is no justification for prescribing PO antibiotics to patients undergoing outpatient open reduction and internal fixation of ankle fractures. Furthermore, inpatients undergoing the same procedure did not show any advantage to postoperative antibiosis and may also not benefit from this practice.

	Inpatient group (IV antibiotics 24hrs)	Outpatient Group 1 (PO antibiotics 24hrs)	Outpatient Group 2 (No antibiotics)	Totals
Number(ankles)	439	483	520	1442
Diabetes	61(13.8%)	71 (14.7%)	68 (13.1)	200(13.9%)
Smoker	131 (29.8%)	121 (25%)	143 (27.5%)	395(27.4%)
HCV/HIV	6 (1.4%)	4(0.8%)	9 (1.7%)	19(1.3%)
Draining Wound	24(5.4%)	29(6.0%)	25(4.8)	78(5.4%)
Infection requiring additional Abx	19(4.3%)	23(4.8)	29(5.6)	71(4.9%)
Infection requiring RTOR	4(0.9%)	3(0.6%)	4(0.7%)	11(0.7%)
*None of these differences are statistically significant				

The Role of Fixation of the Lateral Process of the Talus in Development of Subtalar Arthritis in Patients with Talar Neck or Body Fracture

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Purpose: Development of posttraumatic subtalar arthritis after talar neck and body fractures has been demonstrated to occur frequently and has been shown to correlate with inferior functional outcomes. The primary purpose of this study was to determine if fracture of the lateral process (LP) increases rates of subtalar arthritis in patients sustaining a talar neck or body fracture.

Methods: A retrospective review was preformed at an academic Level I trauma center to identify all patients treated for a talar neck or body fracture. Standard preoperative and postoperative radiographs and CT scans were evaluated for involvement of the LP, the surgical procedure preformed, and the development of subtalar arthritis.

Results: 86 fractures were included, all with greater than 1-year follow-up. 29 (67%) of the 43 talar neck fractures and 14 (33%) of the 43 talar body fractures had LP involvement. 76% percent of talar neck fractures with involvement of the LP developed subtalar arthritis compared to 36% of talar neck fractures without LP involvement (P = 0.035). 30 of the fractures had an independent LP fragment, 12 had no fixation, and all went on to develop subtalar arthritis while 10 of 18 that underwent fixation of the independent fragment developed subtalar arthritis (P = 0.01).

Conclusion: Involvement of the LP of the talus significantly increases the risk for development of subtalar arthritis in patients with talar neck fractures. If a talar neck or body fracture involves the LP, the LP should be treated with reduction and fixation in order to diminish the risk of development of subtalar arthritis.

See pages 401 - 442 for financial disclosure information.

Pathoanatomy of the Tongue-Type Calcaneus Fracture: A Study Using 2 and 3-Dimensional CT

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Purpose: Tongue-type calcaneus fractures are defined by a secondary fracture line that exits posteriorly though the tuberosity, leading to a plantarflexed fragment that is frequently treated using percutaneous techniques (ie, Essex-Lopresti maneuver). Classically, the Essex-Lopresti maneuver levers the tongue fragment out of the plantarflexed position using 2 pins; however, potential angulation in the axial or coronal plane is not addressed. We sought to better define the pathoanatomy of the tongue-type calcaneus fracture to assess the appropriateness of percutaneous techniques as described in addressing all planes of deformity in this injury.

Methods: We reviewed all 1118 calcaneus fractures treated at our Level I trauma center over the past 16 years, identifying 158 displaced tongue-type calcaneus fractures for study. We reviewed cross-sectional imaging to collect all Sanders 2B and 2C fractures (reported to be most amenable to the Essex-Lopresti maneuver). All CT scans were reformatted to be in plane with the malleolar axis in an effort to maintain consistency in the coronal and axial images. We documented the presence of a varus/valgus (coronal plane) or adduction/abduction (axial plane) position of the tongue fragment in relation to the intact subtalar joint, with >10° of angulation being diagnostic of displacement.

Results: Our study cohort consisted of 56 Sanders 2B and 2C calcaneus fractures that were evaluated for angulation in the axial and coronal plane. We found angulation in the coronal plane was common with 77% (43 of 56) tongue fragments in a position of valgus with a mean angulation of 20.8°. The remaining tongue fragments were either without significant angulation (21%) or in a position of varus (2%). In the axial plane, 64% (37 of 56) tongue pieces were in a position of adduction at an average angulation of 20.2°. In the remaining cases, we found 34% without angulation and 2% in abduction. Sanders 2B fractures were more likely to be in a position of valgus and adduction than 2C fractures.

Conclusion: The tongue-type calcaneus fracture most often displaces into a position of plantar flexion, valgus, and adduction. This study is the first of our knowledge to provide a detailed description of the pathoanatomy of the tongue-type calcaneus fracture. Knowledge of this deformity might aid in reduction and establishment of a better reduced subtalar joint when using the Essex-Lopresti maneuver or other less invasive techniques.

The Fibular Nail Experience: Clinical and Patient-Reported Outcomes in 445 Patients

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Purpose: Level-I evidence in small studies has demonstrated the superiority of the fibular nail in successfully fixing ankle fractures while avoiding soft-tissue complications in the elderly and other patients with compromised tissues. There is potential for the fibular nail to benefit the wider population. Our aim was to review a large cohort of patients treated with this device in order to establish the level of success in the general population.

Methods: The clinical and patient-related outcomes of 445 patients who had treatment of unstable ankle fractures with a fibular nail between 2002-2016 were reviewed. Patient records were scrutinized and patient-related outcomes were assessed by postal questionnaires and telephone review to calculate EQ-5D, Olerud and Molander, and Manchester/Oxford Foot and Ankle (MOXFQ) scores. A custom questionnaire was used to identify complications treated elsewhere, return to work, and return to sport.

Results: Of the 445 patients who had undergone fibular nail insertion, 91 were deceased, leaving 354 for review. Mean age at the time of injury was 65 years (range, 14-96) with mean follow-up of 64 months (range, 6-177). Revision surgery due to nail failure was required in 25 patients (5.6%). Metalwork removal was performed in a further 34/29 patients (7.6%, 6.5%): 6 nails and locking screws, 6 proximal locking screws, 2 distal locking screws. Of the 6 nails removed, only 1 was due to infection. Patient-reported outcomes revealed a satisfactory final clinical result with a mean EQ-5D of 0.72 (SD 0.32), a mean Olerud and Molander score of 67 (range, 0-100), and mean MOXFQ score 25 (range, 0-94). All but one of the patients who were working at the time of injury returned to work.

Conclusion: This is the largest series of fibular nails reported to date, demonstrating that low complication rates and favorable outcomes are possible with intramedullary ankle fracture fixation, and can be sustained for up to 14 years postoperatively. These data have driven further implant development and the next generation of the fibular nail will incorporate headless locking screws, with the aim of minimizing soft-tissue irritation and reducing the rate of metalwork removal. The fibular nail should be considered in the management of unstable ankle fractures.

See pages 401 - 442 for financial disclosure information.

Operative Management of AO Type 44 Ankle Fractures: Determinants of Outcome

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Purpose: The consequences of inadequate treatment of ankle fractures can be disastrous. Here we assessed the radiological and functional outcome, the postoperative quality of life, and its determinants of patients operatively treated for AO type 44 ankle fracture. This study faced the lack of evidence concerning the management of posterior malleolus fractures and syndesmotic injuries.

Methods: A retrospective adult cohort study included 432 AO/OTA type 44 ankle fractures (431 patients). Median follow-up was 52 months. Classification was performed by the AO/OTA classification and by combining fibula, medial, and posterior malleolus fractures. Outcome was assessed using the patient files, radiographs, American Orthopaedic Foot & Ankle Society (AOFAS) ankle score (functional outcome), and EQ-5D (quality of life) questionnaires.

Results: The median AOFAS score was 88. 27.9% of the patients reported restricted mobility, 21.1% experienced problems with usual activities, and 40.4% suffered from pain or discomfort. In 8.8%, radiographic failure was observed. The presence of a posterior malleolus fracture was significantly associated with a poor functional outcome, whereby a postoperative step-off correlated with both radiological failure, poor functional outcome, and postoperative quality of life in young and middle-aged patients (≤65 years). Additionally, a syndesmotic injury and delayed-staged surgery protocol were associated with radiological failure, which in turn correlated significantly with AOFAS functional outcome scores. A prolonged time to removal of the syndesmotic screw was associated with worse EQ-5D TTO (time tradeoff) quality of life scores.

Conclusion: A substantial number of our operatively treated patients with an AO type 44 ankle fracture suffered from functional impairment, discomfort, and pain. The presence of a ligamentous (syndesmotic) injury was found to be associated with failure of the ankle joint and subsequently poor functional outcome. Our data indicate that all displaced posterior malleolus fracture fragments affecting the posterior articular tibial surface in patients up to 65 years require an anatomical reduction. This can be accomplished best through direct open reduction and internal fixation via a posterolateral or posteromedial approach. A conscientious diagnostic workup of AO type 44 ankle fractures, the assessment of associated ligamentous injury, and careful treatment are essential for a good outcome.

Outcomes of Early Versus Delayed Postoperative Weight Bearing in Patients Undergoing Surgical Fixation of Ankle Fractures: A Systematic Review and Meta-Analysis

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Purpose: Although indications for surgical intervention for acute ankle fracture are relatively well defined, the postoperative protocol with respect to time to weight bearing (early or late) remain controversial. The purpose of this study was to systematically review early postoperative weight bearing (EWB) compared to late weight bearing (LWB) on functional outcome and complications in adult patients undergoing surgical fixation of ankle fractures.

Methods: A systematic review of the literature was performed to identify studies of randomized clinical trials or matched cohort studies comparing outcomes of EWB (within 2 weeks postoperatively) and LWB (4-6 weeks postoperatively) after surgical fixation of ankle fractures. Randomized controlled trials, as well as nonrandomized prospective cohort studies with a control group, were included. The primary outcome was ankle functional outcome as measured by the Olerud Molander Ankle score (OMA). Secondary outcomes included time off work, and complications such as nonunion, malunion, wound complications, and reoperations.

Results: 10 studies and 633 patients were included at final analysis. The pooled results demonstrated a 10-point improvement in OMA scores at 6 weeks postoperatively for patients in the EWB group compared to the LWB group ($P = 0.02$), but no difference in the long term at 1 year. With regard to time off work there was a trend toward reduction of 15 days in the EWB group ($P = 0.08$). There was no difference with respect to nonunion, malunion, or wound complications between the 2 groups. Patients in the LWB group had a trend toward higher rate of revision surgery (11 of 169 vs 1 of 170, $P = 0.08$), primarily for hardware removal.

Conclusion: This meta-analysis suggests improved early functional outcomes in patients treated with EWB compared to LWB, with a trend toward lower time off work and lower need for revision surgery. The results show no difference in rates of nonunion, malunion, or wound complications between the 2 groups, indicating that early weight bearing is safe. Given the potential for improved outcome and lack of increased risk, early postoperative weight bearing after surgical fixation of ankle fracture is recommended.

See pages 401 - 442 for financial disclosure information.

Clinical and Functional Outcome Following Distal Tibial Fracture Treated by Circular External Fixation

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Purpose: Distal tibial fractures are notoriously difficult to treat and a lack of consensus remains on the best approach. This study examined clinical and functional outcomes in patients with fractures extending within 1 Muller square of the ankle treated definitively by Ilizarov fixation.

Methods: Between July 2011 and 2016, patients with distal tibial fractures were identified from our Ilizarov database. Fractures were classified according to the AO/OTA classification. Functional outcome data, including general measures of health-related quality of life and limb-specific scores had been routinely collected for part of the study period. Patients in whom these data had not been collected were asked to complete these by mail. Adverse events were documented according to Paley's classification of: problems, obstacles, and complications. Data did not meet the assumptions for parametric analysis and therefore nonparametric methods were used.

Results: 168 patients with 169 fractures were identified, 47 (28%) were open and 107 (63%) intra-articular. 164 (97%) of the fractures united (4 nonunions, 1 amputation in a diabetic patient with an insensate limb due to peripheral neuropathy), at a median of 166.5 days (range, 104-to 537; interquartile range [IQR], 138 to 203). 3 nonunions united with further treatment, 2 by Ilizarov frame and 1 by internal fixation. The final nonunion appears to be uniting in a second frame. Closed fractures united more rapidly than open (median 157 vs 183 days; P = 0.005) and true Pilon (43C3) fractures took longer to unite other fractures (median 157 vs 177 days; P = 0.01). 36% of patients encountered a problem, 11% an obstacle, and 9% a complication. Of the complications, 6 (4%) were minor, 5 (3%) major not interfering with the goals of treatment, and 5 (3%) major interfering with treatment goals. Functional outcome data were incomplete; 62% of patients overall had completed an outcome form. Overall 56% reported good or excellent ankle scores at last report, 28% fair and 16% poor. Closed, extra-articular, and non-43C3 fractures had better functional outcome scores than open, intra-articular, and 43C3 fractures, respectively. We hope to improve the completeness of this dataset. General measures of health-related quality of life revealed that these injuries continued to significantly affect patients despite good clinical outcomes.

Conclusion: This study demonstrates a high union and low serious complication rate, suggesting that external ring fixation is a safe and effective treatment for these injuries.

Multi-Dose Prophylactic IV Antibiotics Do Not Lower the Risk of Surgical Site Infection (SSI) for Isolated Closed Ankle Fractures

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Purpose: The regimen of prophylactic intravenous (IV) antibiotics varies. The outpatient regimen for patients being discharged immediately after surgery (single preoperative IV dose, SD) is different from the inpatient regimen for patients remaining in the hospital (multi-dose 24 hours IV postoperative, MD). The purpose of our study was to compare the SSI rates in closed ankle fracture patients receiving either SD or MD.

Methods: We retrospectively reviewed the medical records of 314 patients with isolated closed ankle fractures from January 2012 to June 2016. Data analysis included demographics, risk factors for SSI (DM, BMI>30, immunosuppression, tobacco), IV antibiotic regimen, development of SSI, medical complications, length of hospital stay, and length of follow-up. We defined superficial SSI as those requiring local wound care and oral antibiotics, and deep SSI as those requiring return to operating room for debridement. A post hoc power analysis using a small/moderate effect size demonstrated sufficient power.

Results: 314 patients were included, with 99 in the SD group and 215 in the MD group. The overall SSI rate was 5.1% in the SD group versus 2.8% in the MD group (P = 0.312). The superficial SSI rate was 2.0% in the SD group versus 1.4% in the MD group. The deep SSI rate was 3.0% in the SD group versus 1.4% in the MD group.

Conclusion: The SSI rates in isolated closed ankle fractures receiving either SD or MD perioperative IV antibiotic prophylaxis were similar. Further studies should be considered to help guide standard of care for perioperative IV antibiotic prophylaxis.

Table 1. Descriptive Comparisons, Single Dose vs Multi-Dose (excluding oral abx); N = 314

	Single Dose Only n = 99	Multi-Dose n = 215	Statistical Significance
Gender (% male)	56.6%	43.3%	$X^2 = 4.816$ p = .028
Age Mean years (St. Dev)	44.2 (17.3)	47.7 (19.2)	p = .346
Smoking Status (%)			
Former	10.1%	10.7%	p = .807
Current	26.3%	29.4%	
Never	63.6%	59.8%	
Body Mass Index (%)			
<30	62.0%	62.9%	p = .882
≥30	38.0%	37.1%	
Diabetic (%)	9.1%	12.6%	p = .370
Length of Stay Mean days (St. Dev)	2.3 (2.3)	4.1 (3.7)	t = .5379 p < .001
Fraction Type Count(%)			
Medial mall	1 (1.0%)	8 (3.7%)	p = .067
Lateral mall	12 (12.2%)	26 (12.1%)	
Bimall	28 (28.6%)	90 (42.1%)	
Trimall	40 (40.8%)	69 (32.2%)	
Post mall	1 (1.0%)	3 (1.4%)	
Other	16 (16.3%)	18 (8.4%)	
Infection Rate Count (%)			
Overall Infection	5 (5.1%)	6 (2.8%)	p = .312
Superficial Infection	2 (2.0%)	3 (1.4%)	
Deep Infection	3 (3.0%)	3 (1.4%)	
Medical Complications (%)	7.2%	6.1%	p = .711

See pages 401 - 442 for financial disclosure information.

Risk Factors for Fibular Nail Failure in the Management of Unstable Fractures of the Ankle Joint

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Purpose: The fibular intramedullary nail provides secure fixation, high patient-reported outcome scores, and low complication rates. However, technological developments bring new potential sources of complication and error. The purpose of this study was to review our radiographic failures to determine (1) the frequency of failure of fixation, (2) radiographic risk factors for failure, and (3) a classification of modes of failure.

Methods: We identified 333 cases over an 8-year period that were managed with a fibular nail. All had adequate preoperative, intraoperative, and postoperative radiographs for analysis, with a minimum follow-up to fracture union. Demographic data, fracture classification, and detailed radiographic parameters were recorded. Failed fixations were reviewed in detail including scrupulous assessment of radiographs, and operative and clinical notes. The primary outcome measure was failure of lateral malleolar fixation requiring revision.

Results: There were 332 patients with a mean age of 64 years (range, 14-96 years). The majority were type 44B fractures (272 cases, 82%) and according to Lauge-Hanson 262 cases (79%) were supination-external rotation (SER) type. Syndesmosis injury was seen in 58 cases (17%). Mean radiographic follow-up was 39.5 weeks (range, 6-396 weeks). In 20 patients (6%) the construct failed prior to bone healing, requiring revision. Detailed review revealed loss of locking screw fixation in osteoporotic bone in 4 cases and surgeon error in 16. Failure to implement non-weight-bearing restrictions in cases with associated syndesmotic injury resulted in 8 of the failures. In 5 cases the final intraoperative fluoroscopy images demonstrated inadequate talar reduction or poor nail placement. In 3 cases, the transverse locking screw had simply not been secured tightly. Independent risk factors for failure were pronation-abduction type fractures ($P = 0.035$), syndesmotic injury ($P = 0.006$), poor intraoperative talar reduction ($P = 0.045$), and a proximally sited locking screw >20 mm above the plafond ($P = 0.003$).

Conclusion: Fibular intramedullary nailing offers exciting possibilities for achieving stable fixation while reducing soft-tissue complications. We have reviewed our own experience, which has resulted in the manufacturer modifying the nail design, providing interlocking screws to improve pull-out strength. Surgeons are reminded of the important technical aspects of a successful intraoperative technique and appropriate postoperative management.

Patient Factors Predict Soft-Tissue Complications Following Ankle Fracture Surgery

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Purpose: Forces causing bimalleolar or trimalleolar fracture may be greater than for isolated distal fibular fracture. Poor baseline tissue quality, large body mass, and mechanism will affect severity of displacement. This study investigates factors predictive of soft-tissue complications following ankle fracture.

Methods: 788 ankle fractures were classified as 44B1 or 44B2.1: lateral, posterior, or medial malleolar; 44B2.2 bimalleolar; or 44B3 trimalleolar. Associated dislocations and open fractures were documented. Soft-tissue complications included wound dehiscence and infection.

Results: Mean age was 43 years, mean body mass index (BMI) was 32, and 16% had diabetes mellitus. Most patients with BMI >30 had diabetes. After bimalleolar fracture, presence of neuropathy (P = 0.001) or BMI >30 (P = 0.014) increased the odds of soft-tissue complication by 30.3 and 4.0 times, respectively. Open fractures were predictive of complications after trimalleolar fractures, increasing the odds ratio by 11.7 (P = 0.006). No factors were predictive of soft-tissue complications in patients with isolated medial or lateral malleolar fractures.

Conclusion: Neuropathy and obesity predicted complications. Number of injured malleoli may account for energy of injury and fracture complexity, demonstrating the breadth of difference in the larger Diagnosis Related Group (DRG) 563. While these injuries are reimbursed by DRG, this study shows that outcomes are affected by conditions placing soft tissues at risk. Utility of risk-adjusted reimbursement should be considered to compensate for the expectation of soft-tissue compromise.

Malleolar Group	Soft-Tissue Compromise	Frequency	Percent
1	None	44	75.9%
	Superficial	10	17.2%
	Deep	4	6.9%
	Total	58	100.0%
2	None	162	77.5%
	Superficial	41	19.6%
	Deep	6	2.9%
	Total	209	100.0%
3	None	85	71.4%
	Superficial	31	26.1%
	Deep	3	2.5%
	Total	119	100.0%

Malleolar Group	Mean BMI	Diabetes	Patients w/ BMI>=30	Fisher's Exact
1	30.97	No	28	p=0.425
	34.83	Yes	30	
2	30.81	No	90	p=0.009
	38.09	Yes	119	
3	30.87	No	54	p=0.07
	34.22	Yes	65	

See pages 401 - 442 for financial disclosure information.

Identifying and Reproducibly Clamping Along the Trans-Syndesmotic Axis Using Preoperative CT and Intraoperative Fluoroscopy for Ankle Syndesmotic Reduction

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Purpose: The use of reduction clamps may cause syndesmotic malreduction when an off-axis clamping vector is established. We describe a novel technique for utilizing preoperative CT imaging to plan reduction clamp tine placement along the trans-syndesmotic axis (TSA). The hypothesis of this project is that there exists a way to methodically use preoperative CT to plan clamp placement to reproducibly position an optimal clamping vector across the syndesmosis, using only 2-dimensional (2D) fluoroscopy intraoperatively.

Methods: 25 paired cadaveric, through-knee specimens were imaged using CT. Using a series of standardized measurements, the projected location of the medial clamp tine along the TSA was calculated. This position was recorded as a percentage of the distance between the anterior to posterior cortices of the tibia (tibial line), as would be seen on a true talar-dome lateral using 2D radiography. Syndesmoses were then reduced with the lateral clamp tine placed on the fibular ridge and the medial clamp tine placed on the templated location along the tibial line. Specimens were then reimaged using CT and assessed for the difference between the desired and actual clamping vectors.

Results: The intraobserver reliability for this novel series of measurements was determined to be highly reproducible with an intraclass correlation coefficient (ICC) of 0.979 for measuring the TSA angle and an ICC of 0.980 for the medial clamp tine position along the tibial line. On average, the trans-syndesmotic angle in these specimens measured 22° ± 3° and 19 ± 9% along the tibial line. The average TSA angle difference was 3° ± 2° between paired specimens. The average angle difference between the measured TSA and actual reduction clamp vector was 3° ± 2°, corresponding to 5 ± 4% along the tibial line.

Conclusion: Reduction clamp placement directly along the TSA can be facilitated by preoperative CT measurements to determine the required position of the medial clamp tine using a true talar dome lateral fluoroscopic image as intraoperative guidance. Importantly, this standardized measurement technique demonstrated high reproducibility and paired specimens had similar TSA angles between sides, allowing for the use of the contralateral uninjured ankle in a clinical scenario. On average, we were able to position our reduction clamp vector within 3° ± 2° of the TSA angle calculated preoperatively.

The Influence of Reduction Clamp Position Relative to the Patient-Specific Trans-Syndesmotic Axis Versus Direct Visualization and Manual Palpation on Objective Measures of Ankle Syndesmotic Reduction

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Purpose: There is little understanding of how much tolerance exists for off-axis reduction clamp position relative to the patient-specific trans-syndesmotic axis (TSA). Controversy also exists as to whether or not percutaneous clamping is a superior technique compared to direct visualization with manual digital reduction. The purposes of this cadaveric model were to (1) determine the relationship between malreduction rates at various clamping positions relative to the patient's TSA, and (2) understand if direct visualization or palpation with manual digital reduction is superior to using a percutaneously applied reduction clamp.

Methods: 48 cadaveric through-knee specimens were imaged using CT prior to dissection. Measurements were performed to assess the native fibular position and TSA angle. The syndesmosis was then destabilized according to established protocol. Reduction clamp tines were then placed at positions 10° anterior to the TSA, along the TSA, and at both 10° and 20° posterior to the TSA. CT imaging was performed with the reduction clamp in each position. The unstable syndesmosis was then reduced with manual digital pressure using palpation of the anterior tibiofibular relationship alone, and again separately using direct visualization, to assess reduction.

Results: Palpation and direct visualization produced the overall lowest malreduction rates in all measurements: 4.9% and 3.0%, respectively. Off-axis clamping of >10° anterior or >20° posterior to the patient-specific TSA demonstrated an increased overall malreduction rate (P = 0.02). There was a significant difference in overcompression for all specimens where a reduction clamp was utilized (8.6%), as compared to the groups where manual digital reduction was performed alone (0%) (P = 0.003).

Conclusion: Reduction clamp placement is sensitive to off-axis clamping, particularly when the reduction clamp is placed beyond 10° anterior or 20° posterior to the patient-specific TSA. Use of reduction clamps increases the risk for syndesmotic overcompression compared to manual digital reduction. This study adds to the increasing evidence that routine use of percutaneously applied reduction clamps may lead to an increased number of gross syndesmotic malreductions and should be supplemented by, or replaced with, direct visualization or palpation of the syndesmosis.

See pages 401 - 442 for financial disclosure information.

Does Surgical Approach Influence the Risk of Postoperative Infection Following Surgical Treatment of Tibial Pilon Fractures?

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Purpose: There are a number of surgical approaches to tibial pilon fractures. There is no study that compares the various approaches to pilon fractures as it relates to the risk of postoperative infection. The purpose of this study is to determine whether a particular surgical approach or combination of approaches is a risk factor for infection after open reduction and internal fixation (ORIF) of pilon fractures.

Methods: This is a retrospective review of pilon fractures managed at 2 Level I trauma centers between 2001 and 2015. Data regarding medical comorbidities, closed versus open fracture, use of initial temporizing external fixation, timing of ORIF, and surgical approach were recorded. Fractures were classified according to the AO/OTA system. Multiple logistic regression analysis was used to identify independent risk factors for postoperative infection.

Results: A total of 590 fractures in 581 patients (384 males, 197 females) with a median age of 45 years (interquartile range [IQR], 35-55 years) were reviewed. Open fractures occurred in 24% of the cases. Initial temporizing external fixation was applied to 54% of the fractures. Median time between injury and ORIF was 8 days (IQR, 1-16 days). The most common primary surgical approach used was medial (54%), followed by anterolateral (25%), anterior (11%), posterolateral (8%) and posteromedial (2%). A dual approach to the distal tibia was used in 18% of cases. Fibular fixation was used in 43% of the cases. The deep infection rate was 19%. Univariate regression analysis demonstrated an unadjusted association between infection and several variables: male sex (P = 0.003), smoking (P = 0.003), open fracture (P = 0.004), initial temporizing external fixation (P = 0.001), and AO/OTA 43-C fractures (P = 0.007). Independent risk factors for infection according to multiple logistic regression analysis were: (1) male sex (odds ratio [OR] = 1.9, 95% confidence interval [CI] = 1.2-3.2, P = 0.012), (2) smoking (OR = 2.0, 95% CI = 1.3-3.1, P = 0.003), and (3) AO/OTA 43-C fractures (OR = 1.9, 95% CI = 1.1-3.5, P = 0.03).

Conclusion: Surgical approach does not appear to be a significant risk factor for postoperative infection following ORIF of distal tibial pilon fractures. Independent risk factors for postoperative infection include male sex, smoking, and higher-energy fractures. When treating pilon fractures, surgeons should select the approach they feel best addresses the specific fracture pattern.

Salvage and Stabilization of Limb-Threatening Ankle Trauma in Comorbid, Minimally Ambulatory Patients Utilizing a Retrograde Hindfoot Nail

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Purpose: Limb salvage after major periarticular ankle trauma (ie, open ankle fracture, type C pilon fracture) in the comorbid, low-demand patient is fraught with complication when utilizing conventional treatment strategies. The aim of this study was to evaluate an unconventional treatment alternative that utilizes a hindfoot fusion nail as the stabilization for limb salvage in these hosts.

Methods: In an IRB-approved retrospective study, the charts and imaging of patients who received a retrograde hindfoot nail from January 1, 2010 to January 1, 2015 were evaluated. These patients possessed one or more "vulnerability factors" that have been previously associated with poor traditional fixation outcomes: (1) age >65 years, (2) morbidly obese (body mass index [BMI] >40), (3) extensive soft-tissue compromise or open/impending open injuries, (4) peripheral vascular disease or diabetes, (5) age-adjusted Charlson Comorbidity Index (ACCI) of 6 or above, corresponding with a 2.25% 10-year survival rate, (6) tibial plafond or other comminuted injury pattern. These patients underwent hindfoot nailing without joint preparation, except in cases where debridement was indicated secondary to open fracture care. Our primary outcome was procedure success, defined as remobilization to baseline ambulatory status without amputation. Secondary outcomes included clearance to weight bear as tolerated, surgical site complications, 90-day readmissions, and amputation rate.

Results: A total of 34 patients met at least one of our inclusion criteria, with an average of 3.3 ± 1.2 criteria met. Their mean age was 75.3 ± 16.9 years (70.6% geriatric, defined as ≥65 years of age) and mean BMI was 30.8 ± 10.1 (20.6% morbidly obese, with BMI >40). Of the 26 patients who were not 90-day mortalities or amputations, 23 (88.5%) had successful outcomes. Average time until full weight bearing was 64.7 ± 27.5 days. Two patients (5.9%) required amputations, both from infections (3 total infections, 8.8%). Of the 15 patients who were ambulatory preinjury, 14 (93.3%) were cleared to weight bear as tolerated and returned to ambulation. Eight patients (23.5%) were readmitted within 90 days of stabilization, although only 3 of these were orthopaedic-related.

Conclusion: Use of a hindfoot fusion nail is an effective treatment alternative in sicker, minimally mobile patients after major orthopaedic trauma. This method is associated with an acceptable complication rate, as well as a rapid return to functional capability.

See pages 401 - 442 for financial disclosure information.

Is Time From Surgery to Splint Removal Associated With the Development of Wound Complications Following Ankle Fracture Fixation?

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Purpose: Ankle fractures are the among the most common fractures treated by orthopaedic surgeons. While there have been major advances in surgical protocols to reduce surgical site infections, there is a lack of consensus regarding the best practice for timing of post-operative dressing changes for ankle fracture fixation. The purpose of our study is to compare whether the removal of the post-operative splint prior to hospital discharge compared to maintenance of the post-operative splint until outpatient follow-up had an impact on wound complications of all surgically treated ankle fractures.

Method: A retrospective cohort study of 1,644 ankle fractures treated surgically at two Level 1 trauma centers between March 2002 and November 2014 was conducted. The primary outcome was the rate of wound complications including the presence of any eschar, need for wound care, antibiotics, or surgical debridement. Patient charts were reviewed to determine duration of the post-operative splint and whether it was removed in the hospital prior to discharge or in the clinic at the first post-operative visit.

Results: Of 1,644 ankle fractures which met the criteria for analysis, a total of 380 cases (23.1%) had a wound complication. 304 of these cases required local wound care (18.5%), and 257 of these cases required PO antibiotics (15.6%). 143 of these cases required IV antibiotics (8.7%). OR debridement was required in 130 cases (7.9%), with an average of 2.06 OR debridements required in these cases. 107 of 380 cases of wound complication eventually required removal of hardware due to infection (28.1%). We noted that cases in which the post-operative splint was changed prior to follow-up was associated with a 2.03-fold higher incidence of wound complication ($p < 0.0001$). We noted a 25.62% complication rate in cases where post-operative splint was changed before discharge, compared with 12.62% complication rate in cases where post-operative splint was left intact until follow-up appointment.

Conclusion: When compared to transitioning patients to removable casts during the initial hospitalization, maintenance of the splint applied in the operating room until the first follow-up appointment reduces the risk of wound complications and infection.

Clinical and Functional Outcomes Following Posterior Malleolus Fracture

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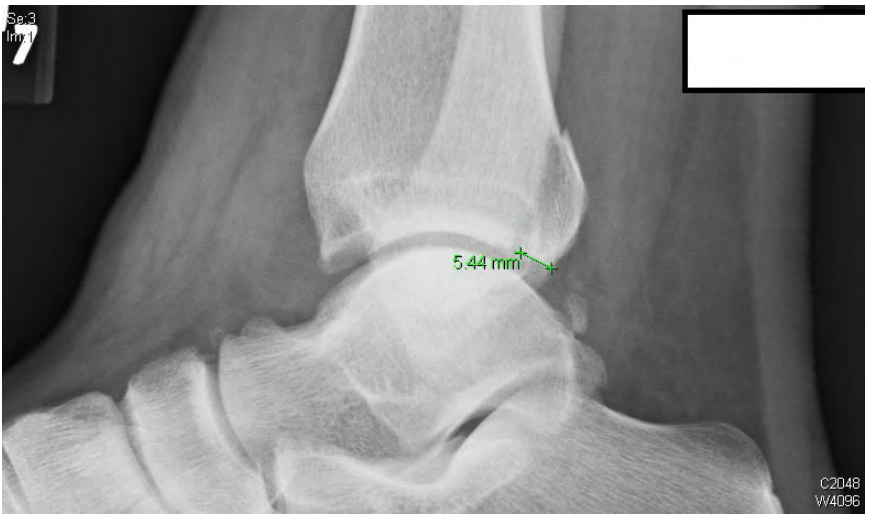
Purpose: Ankle fractures with posterior malleolus fracture (PMF) have higher risk of post-traumatic arthrosis (PTA), but functional outcomes have not been well studied. The purpose was to assess the clinical, radiographic, and functional outcomes after PMF.

Methods: 779 adults had open reduction and internal fixation (ORIF) with (n = 293) and without (n = 486) PMF and were assessed for complications, ankle pain, and employment. Functional outcomes were assessed with Foot Function Index (FFI) and Short Musculoskeletal Function Assessment (SMFA) surveys.

Results: Mean age was 44.6 years, with 13% open fractures. 76.4% were 44B and 23.6% 44C with PMF, and 71.3% were 44B and 28.7% 44C without PMF. Six patients with PMF and 3 without had inadequate reduction, and 12 patients with PMF and 9 without healed with malalignment. 76.9% of those developed PTA; half had a PMF. PMFs more frequently had symptomatic malunion (2.2% vs 0.5% without PMF, P = 0.06), but had similar PTA (35.5% vs 32.5% without PMF) and complications (14.9% vs 12.4%). Mean PMF size was 5.0 mm (15.0% of the articular surface). PMF fragment sizes of <5 mm, 5-10, and >10 had 30.2%, 36.7%, and 58.3% incidence of PTA (P = 0.16) versus 33.3% without PMF. Patients with PMF involving >15% of the articular surface were more likely to develop PTA (52.4% vs 28.1%, P = 0.04). Patients with PMF >10 mm had trends for unemployment (20% vs 2.2%, P = 0.05) and pain after 1 year (90% vs 55.6%, P = 0.074), but no associations between PMF and outcome scores.

Conclusion: PMF fragments involving >15% of articular surface had a higher risk of developing PTA, and fragments larger than >10 mm had trends for more pain and employment limitations. However, presence and size of PMF did not impact outcomes.



See pages 401 - 442 for financial disclosure information.

3D Quantification of Posterior Malleolar Fragment Reduction Predicts Clinical Outcome in Prospective Trial

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Purpose: In ankle fractures involving the posterior tibial margin, articular congruity is believed to be a strong predictor for clinical outcome. In the current prospective study, the aim was to correlate quantitative 3-dimensional CT (Q3DCT) fracture displacement with clinical outcome.

Methods: 31 patients with an ankle fractures including a posterior malleolar fragment were included. Postoperative CT scans were evaluated using Q3DCT modeling techniques. Posterior fragment size (%), postoperative gaps (mm^2), step-off (mm), and overall multidirectional displacement of the posterior fragment were quantified. We evaluated early posttraumatic arthrosis, Foot and Ankle Outcome Score (FAOS) pain and symptoms subscales, AOFAS (American Orthopaedic Foot & Ankle Society), and Short Form-36 (SF-36) at 1 year.

Results: Total gap surface showed a median of 12.6 mm^2 (Fig. 1) but did not correlate with posttraumatic arthrosis, FAOS, AOFAS, or SF-36 scores. However, step-off (median 0.7 mm) (Fig. 2) correlated significantly with FAOS pain and symptoms subscales. The size of the fragment correlated significantly with early posttraumatic arthrosis. Overall multidirectional displacement with a mean of 0.96 mm (SD 0.8) did not show any significant correlation with any of the outcome scores.

Conclusion: In rotational type ankle fractures involving the posterior tibial margin, the size of the fragment and intra-articular step-off significantly correlate with development of early posttraumatic arthrosis and patient-reported pain and symptoms.

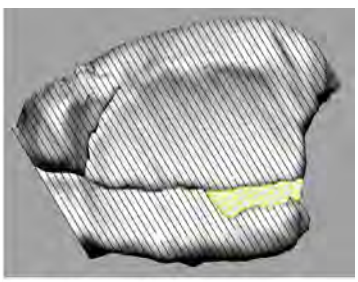

Figure 1. Example of gap surface measurement in mm^2 (yellow grid)

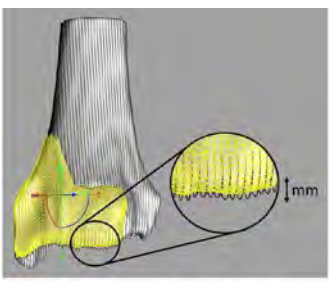

Figure 2. Example of step-off after virtual reduction of fragment

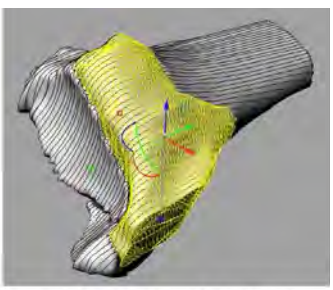

Figure 3. Combined multidirectional displacement is calculated as a vector of displacement in X (blue), Y (green) and Z (red) axis

Negative Impact of Tobacco on Clinical and Functional Outcomes Following Ankle Fracture

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Purpose: Tobacco use has been associated with complications and poor outcomes after orthopaedic injuries. The purpose of this study was to assess the impact of current and former cigarette smoking on clinical, radiographic, and functional outcomes for patients following ankle fracture. We hypothesized that tobacco users would have more complications and worse patient-reported outcomes.

Methods: Smoking history was evaluated in patients who were treated surgically for an acute ankle fracture between 2006 and 2012 at a single Level I trauma center. Medical comorbidities were documented including diabetes, vascular disease, and immune compromise. Clinical outcomes, including early and late complications and need for secondary operations, were reviewed. Social outcomes, such as return to employment and ability to work at full capacity, were also assessed. Patients with >6 months of radiographic follow-up were evaluated for development of chronic pain and posttraumatic arthrosis (PTA). Functional outcomes were assessed using the Foot Function Index (FFI) and Short Musculoskeletal Function Assessment (SMFA) more than 4 years after the injury. For both FFI and SMFA, higher scores indicate worse outcome.

Results: 690 patients were included (47.4% male). Smoking history at the time of injury was categorized as current (n = 324), former (n = 93), and non-smoker (n = 273). Mean ages for current, former, and non-smokers were 42.0, 55.7, and 44.2 years (P <0.0001, younger for current smokers), respectively, and mean body mass index was 29.3, 34.3, and 32.8 (P <0.0001, lower for current smokers). Former smokers were more likely to have medical comorbidities than current smokers and non-smokers (68.5% vs 33.1% vs 44.4%, P <0.0001), respectively. Current smokers were more likely than former smokers and non-smokers to report chronic pain requiring prescription pain medicines (16.7% vs 13.9% vs 4.0%, P <0.037). Former smokers had a greater likelihood than current smokers and non-smokers of having an early complication (16.5% vs 7.2% vs 8.4%, P = 0.028). Patients with any history of smoking had worse FFI scores (3.7 vs 3.1), SMFA Dysfunction (32.6 vs 26.9), and SMFA Bothersome scores (33.1 vs 25.2).

Conclusion: Former smokers were more likely to have comorbidities. However, after accounting for baseline differences, patients with prior or current smoking history at the time of injury had a greater likelihood than non-smokers to have early and late complications, and a greater likelihood to use prescription pain medicines for chronic ankle pain. Patients with any history of smoking had worse FFI and SMFA scores.

See pages 401 - 442 for financial disclosure information.

Tibial Pilon Fractures: Is the Risk for Wound Complications and Infection Still High?

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Purpose: Single center case series indicate that the use of staged protocols, less invasive surgical techniques, and low-profile implants have significantly decreased the rate and severity of soft-tissue complications and infection associated with the treatment of tibial pilon fractures. The goal of this study was to determine if these improvements in techniques are reflected in similarly decreased complications in a much broader and larger series of patients more reflective of the entire population of patients that sustain these injuries. To accomplish this goal we accessed a national database with mid-term follow-up to provide a large series of patients with these fractures, including high and low-volume centers. We assessed the incidence and risk factors for postoperative wound complications. These data come closer to representing the population of patients with these injuries and can be used as a benchmark to stratify patient risk factors and predict rates of wound complications and return to the operating room for these injuries.

Methods: The PearlDiver Research Program was used to query the Humana administrative claims database from 2007 to the third quarter of 2015. The program was used to identify patients who underwent operative fixation of a tibial pilon fracture and any associated complications. Subgroup analysis was performed to investigate patient risk factors for surgical site infection (SSI) including obesity, diabetes, and smoking.

Results: 2330 patients were identified who underwent operative fixation of a tibial pilon fracture during the study period. 296 fractures (12.7%) were open. The overall rate of wound complications was 15.5% (361 of 2330) and return to the operating room for SSI was 9.3% (217 of 2330) at 1 year. Patients with open tibial pilon fractures had the highest rate of return to the operating room for SSI at 19.6% (58 of 296), compared to 7.8% (34 of 2034) in closed injuries. 30.1% (89 of 296 patients) with open fractures experienced a wound complication within the first year after operative fixation. Patients with open fractures (odds ratio [OR], 2.87 [2.06-3.99]; P <0.0001) were at a statistically significant higher risk for SSI. Overall, 539 patients (23.1%) were diabetic, 402 (17.3%) were obese, and 389 (16.7%) were smokers. Rates of obesity and smoking were similar among patients with open and closed injuries (P <0.05).

Conclusion: These data suggests that operative fixation of tibial pilon fractures is still associated with significant rates of wound complications and return to the operating room for SSI, especially when the fracture is open.

Long-Term Function Following Torsional Ankle Fracture

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Purpose: Few studies have examined long-term outcomes after ankle fracture, which are likely variable and dependent on the spectrum of injury, quality of reduction, and medical and psychosocial factors. We hypothesized that greater initial injury severity, including syndesmosis injury and/or dislocation, as well as patient factors would portend worse function and worse scores.

Methods: Functional outcomes were obtained for 166 patients after minimum 5-year follow-up using Foot Function Index (FFI) and Short Musculoskeletal Function Assessment (SMFA). Higher scores indicate worse outcomes. Patients were queried regarding pain, activity limitations, and employment. Radiographs were reviewed for posttraumatic arthrosis (PTA).

Results: 166 patients (52% male) with mean age 53 years and mean body mass index (BMI) 29 were included after 44B (n = 102) or 44C (n = 64) fractures; 20% were open. Isolated ankle injuries occurred in 128, while 12% had ipsi- and/or contralateral (18%) injuries. After mean 91 months, 45% reported unemployment or modified duty, 9% secondary to their ankle, while another 36% had limited or no employment for other reasons. 14% reported some daily ankle pain, with 3% taking prescription medication and 10% using non-prescription medication. PTA was noted in 63%, but was not associated with dislocation (73% vs 56%), open fracture (80% vs 61%), or a complication (88% vs 57%). Worse FFI scores were associated with age <55 years (3.7 vs 2.6, P = 0.02), BMI >30 (4.0 vs 2.9, P = 0.01), Weber C fracture (4.2 vs 3.1, P = 0.04), or complications (4.6 vs 3.3, P = 0.02). Worse SMFA Dysfunction scores were seen with women (33.1 vs 26.1, P = 0.04), age <55 years (32.3 vs 21.3, P = 0.006), BMI >30 (33.7 vs 25.7, P = 0.03), alcohol use (33.6 vs 26.5, P = 0.04), and recreational drugs (46.9 vs 29.5, P = 0.008). Worse SMFA Bother scores were associated with age <55 years (32.7 vs 17.4, P = 0.001), alcohol (33.9 vs 25.4, P = 0.03), and drug use (46.9 vs 29.1, P = 0.02).

Conclusion: After minimum 5-year follow-up a modest number of patients report functional limitations. Although 55% returned to full employment, 14% had daily pain, and worse outcomes were associated with younger age, obesity, and recreational drug use. More severe injuries with associated dislocations, open fracture, and/or Weber C fractures resulted in worse FFI scores, and along with the development of complications, negatively impacted FFI, but not the SMFA.

See pages 401 - 442 for financial disclosure information.

Does Implant Removal Improve Function Following Ankle Open Reduction and Internal Fixation?

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Purpose: Orthopaedic Implant removal (IR) is one of the most common orthopaedic procedures performed, yet there are limited outcome studies on the subject and no guideline exists for when the procedure is beneficial in the lower extremity. The purpose of this study is to evaluate the effect of removal of symptomatic ankle implants using the Short Musculoskeletal Function Assessment (SMFA) dysfunction index as the primary outcome. We hypothesize that IR after ankle fracture will result in improved functional outcomes.

Methods: Utilizing a prospectively collected registry, all patients that underwent IR between 2013 and 2016 were retrospectively reviewed. Inclusion criteria were skeletal maturity, closed intra-articular ankle fracture, symptomatic ankle implants, and completion of the SMFA questionnaire prior to and 5 months after IR. Exclusion criteria were development of a nonunion, infection, or complex regional pain syndrome from initial surgery. The primary outcome was change in SMFA score from baseline. Paired t test was used to compare baseline and follow-up SMFA scores. A multiple linear regression model evaluated the effects of age, sex, body mass index (BMI), smoking status, number of comorbidities, and Lauge-Hansen AO/OTA fracture classification and on outcomes.

Results: The study included 43 patients (31 females, 12 males), mean age 49.9 years (range, 19 to 83). Mean time from initial surgery to IR was 37 ± 46 months (range, 2.2 to 209). Follow-up SMFA questionnaires were completed 5.7 ± 0.5 months (range, 5.1 to 7.4) after IR. The SMFA dysfunction index improved significantly from baseline to follow-up (3.71 ± 7.4, $P = 0.002$). Significant improvement was seen in the secondary outcomes of SMFA bother index (4.40 ± 8.9, $P = 0.003$) and SMFA daily activities domain (4.12 ± 9.1, $P = 0.006$). Regression analysis revealed a significant improvement in the bother index correlating with female gender ($P = 0.01$) and decreasing number of comorbidities ($P = 0.03$).

Conclusion: Our study demonstrates that patients with ankle fractures have a significant improvement in function following the removal of symptomatic ankle implants. There appears to be value in removing implants from the ankle in patients who report discomfort during their daily functions. Further investigation into the specific indications for IR and the impact of injury and fracture pattern on outcomes is warranted.

Δ Outcomes Associated with Early Return to Work and Improved Functional Outcome After Ankle Fracture Fixation

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Purpose: Unstable ankle fractures are generally treated with open reduction and internal fixation. Patient outcomes such as return to work and functional outcome scores depend on many factors, including patient factors, fracture characteristics, and surgical and postoperative protocols. The purpose of this study was to identify factors associated with early return to work and improved functional outcome scores in patients undergoing ankle fracture fixation.

Methods: The results of a previously published randomized controlled trial were utilized. The primary outcome of this study was the rate of return to work at 6 weeks postoperatively, and the secondary outcome was the Short Form-36 Physical Component Summary (SF-36 PCS) score. Clinically relevant patient characteristics were assessed for inclusion in a multivariable model including: age, sex, type of occupation, type of fracture, time to surgical fixation, and type of rehabilitation postoperatively (early weight bearing at 2 weeks or delayed weight bearing at 6 weeks).

Results: In total 110 patients were included for analysis, the mean age was 42 years, and 53% were male. A multivariable model of return to work demonstrated that patients with a sedentary type of occupation were 3.1 times more likely to return to work compared to those with labor/intermediate type of occupations (P = 0.013). There was also a trend toward early return to work in patients with unimalleolar fractures (vs bimalleolar); however, this did not reach statistical significance (odds ratio [OR] = 2.1, P = 0.085). Age and type of postoperative weight-bearing protocol had no effect on return to work. When assessing SF-36 PCS scores, patients treated with early weightbearing protocol had a 9-point increase in SF-36 PCS scores, compared to those with delayed weight bearing (P = 0.005); and patients with a sedentary type occupation had a 9-point increase in SF-36 PCS scores, compared to those with labor/intermediate occupations (P = 0.01). Age, sex, type of fracture, and time to surgery had no significant effect.

Conclusion: This study suggests that early return to work is significantly affected by the type of occupation (sedentary), and potentially the type of fracture (unimalleolar fracture). Early postoperative weight bearing has a significant effect on improving patients' functional outcome, and should be encouraged. This study suggests that patients with intermediate/labor occupations have lower subjective physical function scores, and require longer time off work.

Δ OTA Grant

See pages 401 - 442 for financial disclosure information.

Immediate Weight Bearing After Operative Treatment of Bimalleolar and Trimalleolar Ankle Fractures: Does It Get Patients Back to Work Earlier?

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Purpose: Open reduction and internal fixation is standard treatment for displaced ankle fractures. Postoperatively, most physicians utilize a 6-8 week period of non-weight bearing (NWB). Recent studies have shown improved functional outcomes for early weight bearing as tolerated (WBAT) protocols, although no benefit in return to work has been demonstrated. We evaluated the effect of immediate WBAT on return to work after operative treatment of ankle fractures. Secondarily, we determined the effect of the physical job demand on return to work. We hypothesized that immediate WBAT after operative management of bimalleolar and trimalleolar ankle fractures would result in an earlier return to work.

Methods: We retrospectively reviewed a prospective ankle outcome registry for patients operatively managed from 2010-2015. Prior to the initiation of a WBAT porotocol in 2013, patients underwent immobilization and NWB for 6 weeks. Work status, physical job demand, return to light duty, and return to full duty were recorded during survey. Demographics, fixation technique, and AO/OTA and Lauge-Hansen classification were collected for all patients. A stepwise multiple linear regression and a 2-sided t test were performed.

Results: 34 patients (49%) were treated WBAT and 35 were treated NWB. 65% in WBAT and 71% in NWB ($P = 0.60$) were AO/OTA 44B. All patients returned to work postoperatively. A similar percentage of patients returned to light work in each (32% for WBAT vs 40% for NWB, $P = 0.49$). The WBAT group returned to work earlier than the NWB group approaching statistical significance (5.5 ± 4.7 vs 8.3 ± 8.1 weeks, $P = 0.08$). In subgroup analysis, examining patients with higher physical demands, the WBAT protocol resulted in statistically significant earlier return to work ($n = 19$, 5.7 ± 3.3 weeks) compared to NWB ($n = 26$, 10.0 ± 8.6 weeks) ($P = 0.04$). Longer time to weight bearing ($\beta = 0.08$, $P = 0.04$) and treatment by physician A ($\beta = 0.41$, $P = 0.01$) were predictors of longer return to full work. Sedentary job demand ($\beta = -0.42$, $P = 0.01$) and return to full work with no light work period ($\beta = -0.49$, $P < 0.01$) were predictors of shorter return to full work.

Conclusion: For those with non-sedentary jobs, early WBAT after operatively managed ankle fractures results in earlier return to work. In a carefully selected patient population with high-demand vocations, early WBAT may result in economic benefits through an earlier return to work.

Risk Factors for Tibial Plafond Nonunion

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Purpose: Tibial plafond nonunion following open reduction and internal fixation has been reported to occur in 2-10% of patients. The purpose of this study was to identify the risk factors associated with development of tibial plafond nonunion.

Methods: Following IRB approval, we retrospectively reviewed all plafond fractures treated at 2 Level I trauma centers from 2006-2015. We included patients >18 years of age with a minimum of 6 months follow-up. Nonunion was defined as failure to achieve bridging on >3 cortices with clinical pain after 9 months, catastrophic implant failure, or failure of radiographic progression. Patients with a planned bone grafting were not placed in the nonunion group unless the procedure failed. Substantial bone loss was defined as patients who underwent staged bone grafting, received >15 cc bone graft, or had operative reports documenting substantial bone loss. Minimal bone loss was defined as patients who received <15 cc bone graft or had documented minimal bone loss present. We performed univariate analysis on risk factors using chi-square and Student's t test. Using variables with P <0.2 in univariate analysis, we performed step-wise multiple regression modeling looking for factors with P <0.05 for significance.

Results: During the study period, 705 tibial plafond fractures were treated and 509 patients met inclusion criteria. Mean age was 44 years (range, 18-76 years), mean follow-up was 25 months (range, 6-115 months), and there were 71% male patients. 135 fractures were open injuries (135 of 509, 27%). Overall infection rate was 12% (63 of 509), and deep infection rate was 9% (46 of 509). 67 patients (of 509, 13%) developed nonunion, with 44 aseptic nonunions and 13 septic nonunions. Using univariate analysis, comminution zone, OTA 43C fracture, open fracture, varus/valgus presentation, presence of fibula fracture, Weber fibula fracture classification, bone loss, locked plating, and treatment of medial column were all found to be significant. These variables, along with tobacco use, fracture zone, and approach, were included in step-wise analysis. Using regression analysis, we found significant bone loss (odds ratio [OR] = 2.6, 95% confidence interval [CI] 1.8-3.8, P <0.001), failure to treat the medial column (OR = 0.6, 95% CI 0.4-0.9, P = 0.006), and tobacco use (OR = 2.1, 95% CI 1.1-3.9, P = 0.03) as significant risk factors for tibial plafond nonunion.

Conclusion: Tibial plafond nonunion was 13%. Significant bone loss, failure to treat the medial column, and tobacco use were all significant risk factors for developing nonunion. Approach and locked plating were not significantly associated with plafond nonunion.

See pages 401 - 442 for financial disclosure information.

Does Resident Participation in the Surgical Fixation of Hip Fractures Increase Operative Time or Affect Outcome?

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Purpose: Hip fracture fixation is commonly performed at teaching hospitals with resident support and in community hospitals. It is unknown to what extent participation by residents affects operative times or outcomes.

Methods: 314 patients with hip fractures (AO/OTA A1-3, B1-3) were treated with surgical fixation (177 patients at the community hospital, 137 at the teaching hospital). Demographic and hospital data were collected retrospectively. All operations were performed by one of three board-certified orthopaedic surgeons with clinical appointments at both hospitals. Differences in operative time, estimated blood loss (EBL), transfusion requirement, length of stay, discharge to skilled nursing facility (SNF), and 30-day mortality were evaluated. Multivariate regression assessed the effect of location adjusting for age, gender, and Charlson Comorbidity Index.

Results: At the community hospital we found lower median operative time (46 minutes [95% confidence interval (CI): 43, 52]) versus 75 minutes (95% CI: 70, 81)) and lower EBL (177.3 mL [95% CI: 158.6, 195.1] vs 234.8 mL [95% CI: 196.4, 273.6]). When compared by fixation type, the community hospital had shorter median operative times in 5 of the 6 fixation types analyzed, including: cannulated screws, short intramedullary nail, noncemented hemiarthroplasty, sliding hip screw, and long intramedullary nail. We found no difference in rate of transfusion, length of stay, or discharge to SNF. The unadjusted 30-day mortality was 1.7% (95% CI: 0.35, 4.87) at the community hospital compared to 5.1% (95% CI: 2.08, 10.2, P = 0.11) at the teaching hospital. The adjusted odds ratio for 30-day mortality at the teaching hospital was 5.44 (95% CI: 1.22, 24.1, P = 0.026). The Charlson comorbidity score demonstrated an association with 30-day mortality with an odds ratio of 1.61 (95% CI: 1.19, 2.18, P = 0.018).

Conclusion: The current study shows an increase in operative time and 30-day mortality when residents participate in surgical fixation of hip fractures. While resident involvement in surgical procedures is essential for future competency, it is important that it not come at the expense of patient outcomes. Further research is warranted to evaluate what increase in operative time we can accept in order to teach, and what difference in outcomes, if any, is acceptable.

Validity of Tip Apex Distance as a Predictor of Failure in Cephalomedullary Nails: A Single Center Study

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Purpose: The concept of tip apex distance (TAD), introduced in 1995 by Baumgaertner et al, established a simple guide for optimal lag screw placement on orthogonal films of the hip mainly using side plating. With the recent rise in the use of cephalomedullary nails, the goal of this study is to add to the body of data and evaluate the use of TAD in cephalomedullary nails, and explore any nuances in the distribution of failure and success at our center.

Methods: Patients who underwent cephalomedullary nail fixation for a proximal femoral fracture from April 2004 to July 2011, who were 18 years of age, and had at least 3 months of follow up were retrospectively reviewed. Exclusion criteria included lesion within the femur, inadequate films, incomplete medical record, different type of implant, prior hip fracture, or preexisting deformity. Outcomes were categorized as cutout, failure, nonunion, or healed. Cutout was defined as penetration of the tip of the lag screw or blade through the articular surface of the femoral head. Standard postoperative instructions were issued to all patients allowing weight bearing to tolerance initially with follow-up at 2 weeks, 6 weeks, and 3 months.

Results: A total of 677 femur fractures were retrieved, of which 235 fractures met inclusion criteria. Fractures were excluded for less than 3 months of follow-up, incomplete data, inadequate films, and different type of implant. There were 183 implants with a TAD <25 mm and 52 patients with a TAD >25 mm. 215 implants had no implant complications, 12 had cutout, 5 required revisions for nonunion, and 3 had breakage of implants. The mean TAD was 23.51 ± 10.10 mm for implants that cut out, 21.30 ± 9.37 mm for breakage, 13.35 ± 4.77 mm for nonunion, and 20.10 ± 7.77 mm for successful union. Implants with a TAD >25 mm were significantly (P = 0.002) more likely to have cutout occur (13.5%) compared to those with TAD <25 mm (2.7%).

Conclusion: The goal of this study was to scrutinize TAD <25 mm against the outcomes of cephalomedullary fixation of peritrochanteric hip fracture at a single institution. Our study confirms the previous literature supporting the value of TAD >25 mm as a predictor of screw cutout. Within our cohort of cephalomedullary nails, the TAD value of 25 mm as a maximum cutoff in preventing cutout remains statistically significant (P = 0.002) and constructs with a TAD >25 mm were 5 times more likely to cut out.

See pages 401 - 442 for financial disclosure information.

Targets or Tariffs, or Something Else? A 16-Year Experience with Hip Fractures from a Regional Trauma Center

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Purpose: In the United Kingdom, national guidelines recommend surgery for hip fractures on the day of admission or the following day, with some regions receiving financial incentives for related targets. The Royal Victoria Hospital's 30-day mortality rates have been recognized as among the best in the National Hip Fracture Database, reducing from 7.5% in 2000 to 4.4% in 2014, despite fewer financial incentives and greater waiting times than many other units. The aim was to identify possible factors contributing to the low 30-day mortality rates in this unit.

Methods: Data for all hip fracture admissions from January 2000 to December 2015 were retrieved from the hospital inpatient database. All surviving patients had telephone follow-up up to 1 year.

Results: The database identified 15,345 patients (865 to 1066 annually). By 2015, mean age had risen to 80 years, and 24.7% of operated patients were American Society of Anesthesiologists (ASA) grade 4 or 5, compared to 7.4% in 2000. During this period there was rationalization of treatment towards evidence-based guidance, with increased rates of more complex procedures (eg, total hip arthroplasty and cephalomedullary nailing). Despite improvements in waiting times, most patients received surgery over 36 hours post-injury. Between 2011 and 2015, it was observed that patients who underwent surgery after 36 hours had significantly better 30-day survival than those operated on within 36 hours, especially among ASA 3 and 4 patients, even if delays were due to resource limitations. This finding was contrary to the national recommendation for surgical waiting times for optimized survival. As the operative plan was unaffected by waiting time, it appears that the high level of ward-level medical care is a key factor, as this unit has a dedicated consultant orthophysician-led on-site medical team.

Conclusion: We believe that our early mortality results are attributable to compliance with evidence-based guidance and the high-intensity orthophysician input available. The disparity between waiting time and early mortality results suggests that the current focus on operative waiting times may not be the most relevant parameter in determining early postoperative outcomes after hip fracture.

Opportunistic CT Screening for Osteoporosis in Patients with Pelvic and Acetabular Trauma: Technique and Potential Clinical Impact

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Purpose: Our objective was to present a novel technique for the use of CT scans in opportunistic screening for osteoporosis in patients with pelvic and acetabular fractures, and to quantify the potential clinical impact in a geriatric trauma population.

Methods: Records of patients >60 years of age presenting to a Level I trauma center with pelvic and acetabular fractures evaluated with a CT scan between 2010-2016 were reviewed. A subset of patients with both a CT scan and DEXA (dual-energy x-ray absorptiometry) scan performed within 12 months were selected, and the Hounsfield Units (HU) measured using a standardized, ovoid section of the femoral neck. Livewire segmentation was then used to collect the HU for the entire bone at the respective slice and in the medullary cavity. Both methods were used independently to run a discriminant function analysis using the HU parameters to establish a normal bone mineral density (BMD), osteopenia, and osteoporosis according to the accepted T-score parameters. The CT scans of 335 patients were evaluated using the discriminant function equation and the medical records reviewed for documentation of osteoporosis, osteopenia, or history of fragility fracture.

Results: 255 patients were identified with both CT scan of the pelvis and DEXA. CT thresholds were 345 HU for osteopenia and 262 HU for osteoporosis. The discriminant function equation using the fitted ovoid over the femoral neck had the highest overall percent correct (71.8%). Nonpathological individuals were identified correctly 71% of the time, and osteopenic individuals were identified correctly 67.5% of the time (18.3% were grouped with osteoporotic). Osteoporotic patients were identified correctly 88.9% of the time (the remaining 11.1% were assigned to osteopenic). The overall chi-squared test was significant (Wilks λ = .462, chi-square = 194.383, 2 degrees of freedom, canonical correlation .733, P <0.001). 11.3% of geriatric patients (38 of 335) with pelvic/acetabular trauma presented to our trauma center with a preexisting diagnosis of osteoporosis. After applying the CT screening model, 48 patients were identified as having osteopenia (14.3%) and 188 as having osteoporosis (56.1%). The potential number of newly diagnosed patients with osteoporosis was 156, representing a 387.5% increase in diagnosis.

Conclusion: CT imaging can identify patients with osteoporosis without additional radiation exposure or cost. Routine screening with this protocol may lead to earlier detection and treatment of osteoporosis, thus decreasing the incidence of fragility fractures.

See pages 401 - 442 for financial disclosure information.

Effect of Preoperative Rivaroxaban Use on the Treatment of Femur Fractures for Geriatric Patients

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Purpose: With an increasing geriatric population, the number of patients being treated with novel oral anticoagulants (NOACs) at the time of a geriatric femur fracture is likely to increase. The influence of NOAC usage on operative treatment of femur fractures is not well studied. The objective of this study is to evaluate the effect of preoperative NOAC usage on time to operative treatment (TOT) for geriatric femur fractures and the rate of postoperative complications and transfusion rates associated with NOAC usage.

Methods: CPT codes were used to identify all patients 65 years and older undergoing operative treatment of a femur fracture (OTA/AO 31A-C) over a 4-year period at a university-based hospital. Chart review identified patients taking warfarin, clopidogrel, or rivaroxaban at the time of injury. A control group of patients not anticoagulated were also identified. Demographic data, TOT, transfusion rate, admission hemoglobin/hematocrit (hgb/hct), length of stay (LOS), and 30-day mortality were obtained.

Results: Table 1 details data points for each group. **Analysis of variance revealed a significant difference only for TOT between the warfarin group and the control group of 6.8 hours, $P < 0.05$, SD 2.35 (95% confidence interval, 2.12-11.41).

Conclusion: Our data suggest that patients anticoagulated with rivaroxaban at the time of fracture did not experience significant delays to operative treatment compared to the control group. Rivaroxaban does not seem to confer a heightened 30-day mortality risk or extended LOS in this small cohort. The rivaroxaban group also was found to undergo transfusion of packed red blood cells at twice the rate of the control group.

	Control (n=97)	Warfarin (n=49)	Plavix/ASA (n=29)	Rivaroxaban (n=10)
Ave Age (yrs)	83	87	84	81
Gender (M:F)	15:82	16:33	10:19	10:0
TOT (hrs)	21.4	28.2**	20.5	22.6
Transfusion rate	50.5 %	44.9%	58.6%	90%
Admit hgb/hct	12/37	12/36	11/35	11/34
LOS (days)	5.6	7.0	6.7	6.7
Mortality Rate	4.6%	20.4%	6.9%	0%

Malnutrition Is Associated with Nonunion, Infectious Complications, and Mortality After Geriatric Distal Femur Fracture

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Purpose: There is a growing understanding of the high rates of morbidity, mortality, and nonunion after geriatric distal femur fracture. Limited studies in other cohorts have demonstrated a relationship between malnutrition and mortality; however, this relationship has not been investigated in the geriatric distal femur fracture population. The purpose of our study was to determine the relationship between malnutrition, as evaluated by serum parameters, and mortality, complications, and nonunion following open reduction and internal fixation (ORIF) of the low-energy geriatric distal femur fracture.

Methods: We conducted a retrospective review of patients over the age of 60 years who sustained a distal femur fracture (AO/OTA 33) following a low-energy injury and were treated with ORIF over an 11-year period (2004-2015) at 3 affiliated institutions. Albumin, prealbumin, total protein, and total lymphocyte count (TLC) during the initial hospitalization were collected from the medical record. Patients were excluded if laboratory data were not available. Primary outcomes were nonunion, defined as need for secondary surgery to promote fracture union, mortality, and infectious complications including pneumonia, urinary tract infection (UTI), and surgical site infection (SSI).

Results: 72 patients were identified for inclusion. The average age was 77 years. 59 patients (82%) had albumin <3.5 mg/dL and met established criteria for malnutrition. 18 patients (25%) were deceased at 1 year. Decreased serum albumin (2.8 mg/dL vs 3.2 mg/dL, P <0.03) and decreased total protein (5.3 mg/dL vs 6.1 mg/dL, P <0.02) were significantly associated with increased 1-year mortality. 11 patients developed nonunion (15%). Albumin was significantly lower in the group that developed nonunion (2.7 mg/dL vs 3.1mg/dL, P <0.05). There were 21 infectious complications (2 SSI, 4 pneumonia, 13 UTI, and 2 *Clostridium difficile* infections), and albumin <3.5 was associated with a significantly increased risk of postoperative infectious complications (P <0.02).

Conclusion: Malnutrition, specifically hypoalbuminemia, is associated with a significant increase in 1-year mortality, nonunion, and postoperative infectious complications following ORIF of geriatric distal femur fracture. The majority of patients who sustain this injury demonstrate objective markers of protein malnutrition. Measurement of serum albumin may help provide prognostic information prior to distal femur ORIF. Additionally, while many patient-related factors are nonmodifiable, especially in the acute fracture setting, nutritional status may represent a modifiable risk factor for poor outcomes and deserves further study.

See pages 401 - 442 for financial disclosure information.

Intramedullary Nailing for Atypical Femoral Fracture with Excessive Anterolateral Bowing

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Purpose: Intramedullary (IM) nailing is the treatment of choice for atypical femoral fractures (AFFs). However, several problems, such as iatrogenic fracture and medial gap opening, can occur during IM nailing when AFFs are associated with excessive anterolateral bowing. To overcome these problems, we have developed a new grading system for anterolateral femoral bowing and a new technique for IM nailing. The purposes of this study were (1) to introduce a new grading system and new IM nailing technique for AFF with anterolateral femoral bowing and (2) to compare the postoperative outcomes between the new technique and the conventional technique for IM nailing.

Methods: The new grading system was divided into 3 grades according to the position of the reference line at the apex of the curve of the anterolaterally bowed femur on a true AP view radiograph. The reference line is drawn from the tip of the greater trochanter to the center of the intercondylar notch. The core of the new IM nailing technique is matching the anterior curvature of the femoral nail with the anterolateral bowing of the femur when the nail passes the apex of the curvature, by rotating the nail externally. From January 2005 through March 2016, 24 female patients (30 cases) who underwent surgery for AFF with anterolateral bowing at 2 institutes were evaluated retrospectively. The postoperative outcomes (anterolateral bowing grade, anterior and lateral bowing angle, medial gap and posterior gap of the fracture site, iatrogenic fracture, and time to initial medial callus formation and bone union) were compared between the new technique (group A, 18 cases) and the conventional technique (group B, 12 cases).

Results: The interobserver and intraobserver reliability of the new grading system demonstrated an almost perfect agreement ($kappa_{inter}$ = 0.893, $kappa_{intra}$ = 0.883). There were no significant differences in the preoperative factors between two groups. The differences between the preoperative and postoperative anterior and lateral bowing angles were significantly less in group A (p = 0.013 for both). The medial and posterior gaps of the fracture site were also significantly less in group A (P_{med} = 0.013, P_{post} = 0.022). Iatrogenic fracture occurred only in group B, affecting 2 cases. The time to initial medial callus formation was significantly shorter in group A than in group B (P = 0.033).

Conclusion: Our new grading system for anterolateral femoral bowing is convenient and reliable. Furthermore, the new IM nailing technique with the current IM nail system is appropriate for the repair of AFFs with excessive anterolateral bowing.

Δ Decreased Core Muscle Size Is Associated with Increased 1-Year All-Cause Mortality in Elderly Orthopaedic Trauma Patients

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Purpose: Sarcopenia has been identified as a predictor of worse outcomes and mortality in elective surgery and oncology patients; however, there is limited knowledge on the role of sarcopenia in elderly trauma patients. The study aim was to investigate the association between psoas cross-sectional area (CSA) and 1-year all-cause mortality in elderly trauma patients. We hypothesized that sarcopenia is associated with a higher risk of 1-year all-cause mortality in patients suffering from traumatic pelvic and long bone injuries.

Methods: We retrospectively reviewed the demographic data, ISS, injury mechanism, soft-tissue injuries, fracture type, admission laboratory data, and complications based on the National Surgical Quality Improvement Program guidelines and mortality in 558 patients ≥65 years old admitted to our Level I institution from 2007-2014 for sustained long bone and/or pelvic fractures. Fractures were classified according to the AO/OTA Fracture Classification. Patients underwent an abdomen/pelvis CT scan at admission as part of routine evaluation and axial images were used to assess sarcopenia by measuring psoas CSA at the L3-L4 intervertebral disk space. Patients' psoas CSAs were grouped into quartiles (Q1-Q4). Logistic regression was used to estimate the odds ratios (ORs), 95% confidence intervals (CIs), and P values for 1-year all-cause mortality by quartiles of psoas CSA. Models were adjusted for age, ISS, body mass index (BMI), and albumin.

Results: A total of 706 fractures were identified. The acetabulum/pelvis was most commonly fractured (37.81%) followed by the radius/ulna (22.58%) and femur (22.04%). The majority of fractures were closed (76.34%). A statistically significant association was observed between CSA and 1-year all-cause mortality (10.1% vs 28.8% respectively, P = 0.0010). Non-sarcopenic (Q4) patients had lower odds of all-cause 1-year mortality versus sarcopenic patients (Q1); 0.38 (95% CI = 0.16-0.88), P = 0.024.

Conclusion: In this cohort of elderly orthopaedic trauma patients, sarcopenia was associated with increased prevalence of 1-year all-cause mortality. Further investigation of the ability of sarcopenia to predict mortality and worse outcomes in the elderly is warranted.

Δ OTA Grant

See pages 401 - 442 for financial disclosure information.

How Does Frailty Factor into Mortality Risk Assessment of a Middle-Aged and Geriatric Trauma Population?

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Purpose: Frailty in elderly trauma populations has been correlated with increased risk of morbidity and mortality. The Score for Trauma Triage in the Geriatric and Middle-Aged (STTGMA) is a validated and published mortality risk tool that evaluates age, comorbidities, vital signs, and anatomic injuries. It includes frailty factors such as cognition and general health status; however, it does not include other frailty factors such as disability, functional independence, or nutritional status. We sought to investigate whether the addition of these other frailty variables would improve risk stratification.

Methods: Patients 55 years and older who met the American College of Surgeons Tier 1-3 criteria and/or who had orthopaedic or neurosurgical traumatic consultations in the emergency department at a Level I trauma center from October 1, 2014 to September 30, 2016 were enrolled. Variables collected included energy mechanism, age, Glascow Coma Scale (GCS), Abbreviated Injury Scale (AIS) for Head/Neck, Chest, and Extremities, and Charlson Comorbidity Index (CCI). Additional "frailty variables" included preinjury assistive device use, ambulatory status, and albumin level. The primary outcome measure was in-hospital mortality. The "frailty variables" were introduced into the original STTGMA model (STTGMA_Original) and a backwards stepwise logistic regression was performed to create a new STTGMA_Frailty tool. The area under the receiver operating characteristic curve (AUROC) for STTGMA_Original and STTGMA_Frailty were compared.

Results: There were 1486 patients who met inclusion criteria of which 492 (33.1%) were high-energy (HE) and 994 patients (66.9%) were low-energy (LE) mechanisms of injury. The mean age was 77.2 ± 11.77 years. There were 23 high-energy inpatient mortalities (4.7%) and 20 low-energy inpatient mortalities (2.0%). The AUROC for STTGMA_Original for the HE and LE cohorts was 0.926 and 0.896, respectively. The regression model revealed that the only frailty variables that were independent predictors of mortality were albumin for the HE cohort and ambulatory status for the LE cohort. The AUROC for STTGMA_Frailty for the HE and LE cohorts was 0.905 and 0.937, respectively. There was no significant difference in predictive capacity between the 2 models for both the HE and LE cohorts.

Conclusion: The original STTGMA tool accounts for important frailty factors including cognition and general health status. These variables combined with other major physiologic variables such as age and anatomic injuries appear to be sufficient to adequately and accurately quantify inpatient mortality risk.

The Financial Cost of Early Inpatient Mortality in High-Risk Middle-Aged and Geriatric Trauma Patients at a Level I Trauma Center

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Purpose: Aggressive life-extending procedures in the severely injured middle-aged and geriatric trauma patient during the early phase of admission are associated with high costs. The ability to identify these patients has the potential to create avenues for intervention early in the resuscitation process, thereby decreasing hospital costs and improving patient and/or family expectations. We sought to (1) determine the cost of care for patients who die within the first 2 days of admission and (2) demonstrate that a validated trauma triage score could identify these high-risk patients.

Methods: Patients 55 years and older who were evaluated in the emergency department setting by the orthopaedics department or who met American College of Surgeons Tier 1-3 criteria and were admitted to a single Level I trauma center between October 1, 2014 and September 30, 2016 were prospectively enrolled. On initial evaluation, each patient's demographic, injury severity, and functional status were utilized to calculate a STTGMA score (Score for Trauma Triage in the Geriatric and Middle-Aged Orthopaedic Trauma Patient, a validated and published trauma risk score). Length of stay, inpatient mortality, time between admission and time of death, and hospitalization costs were recorded for each patient. Patients who died within 48 hours of presentation and those who did not were compared using significance of $P < 0.05$.

Results: A total of 1470 consecutive patients (mean age of 72.2 ± 11.9 years) were enrolled in this study, 17 (mean age of 78.0 ± 12.5 years) of whom expired within 48 hours of admission. The average time of death in patients who died during index admission was 13.2 ± 15.6 hours. These patients had higher trauma triage scores than the rest of the cohort with a score of 50.9 ± 37.2% versus 3.3 ± 9.5% ($P < 0.0001$), indicating that they had a mean risk of inpatient mortality of over 50%. Mean total cost/day was much higher in the cohort of patients who died within 48 hours of admission compared to all other trauma patients ($49,367 ± 79,057 vs $3966 ± 2,897; $P = 0.031$). This increase in cost/day seen in the cohort of patients who expired within 48 hours of admission was also seen in several cost buckets of care, including room, radiology, and cardiology.

Conclusion: This study demonstrates the ability of the STTGMA score to triage middle-aged and geriatric trauma patients who are at high risk for early inpatient mortality. To achieve value-based care in this high-risk cohort, targeted cost savings while improving patient outcomes and/or expediting end-of-life goals is necessary and the STTGMA score allows for stratification of these patients in both mortality risk and cost profile.

See pages 401 - 442 for financial disclosure information.

Application of Clinical Practice Guidelines: Differences in Management of Femoral Neck Fractures by Trauma or Arthroplasty Training

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Purpose: The purpose of this study was to survey Trauma (TS) & Arthroplasty Surgeons (AS) to investigate associations of specialty and treatment for displaced elderly femoral neck fractures (FN Fx) & to compare them to clinical practice guidelines (CPG).

Methods: 556 surgeons completed an online survey through either the OTA or AAHKS websites. Respondents identified their specialty as TS (9%), Arthroplasty (70%), other (5.5%), none (14.5%), or both(1%). The survey consisted of 2 sections: 1) surgeon demographic and practice information; & 2) two FN Fx cases with affiliated questions regarding treatment based on CPG familiarity, validity and applicability.

Results: TS were less likely than AS to recommend total hip arthroplasty (THA) and spinal anesthesia in both cases(Table 1). There were no differences between the groups in cement use, uni- or bipolar hemiarthroplasty (HHA) use, or approach. Surgeons under age 40 were more likely to use cement ($p<.05$), regardless of specialty. Familiarity, training, and CPGs were the most important factors driving decision making while cost,implant availability,& case duration were less important.

Conclusion: AS are more likely to recommend THA over HHA and request spinal rather than general anesthesia for the treatment for displaced FN Fx in the elderly. Overall, most surgeons are familiar with CPGs and believe they are supported by the literature, but few have changed their practice as a result.

Table 1. Arthroplasty and Anesthesia Preferences for Trauma and Arthroplasty Surgeons

	Case 1	HHA	THA		p	Case 2	HHA	THA		p
Trauma		6 (12%)	42 (84%)				45 (90%)	5 (10%)		
Arthroplasty		14 (4%)	370 (96%)		0.01		277 (71%)	112 (29%)		0.02
	Case 1	General	Spinal/reg.	Defer	p	Case 2	General	Spinal/reg.	Defer	p
Trauma		11 (22%)	20 (40%)	19 (38%)			6 (12%)	19 (38%)	25 (50%)	
Arthroplasty		50 (13%)	272 (70%)	68 (17%)	<0.01		56 (14%)	241 (62%)	93 (24%)	<0.01

Survival of Acute Total Hip Arthroplasty Following a Femoral Neck Fracture

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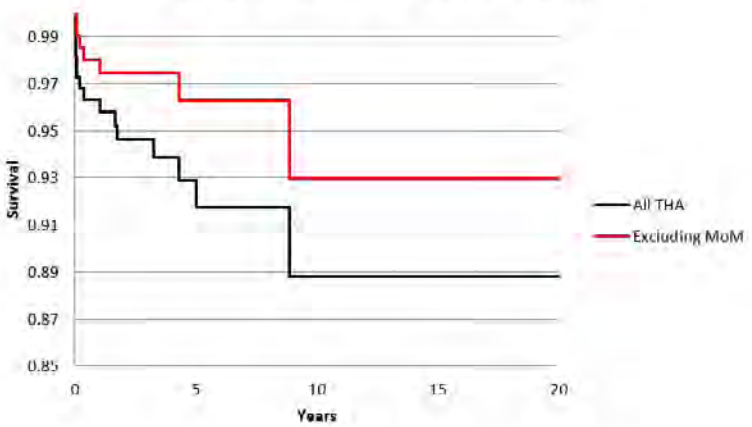
Purpose: Femoral neck fractures (FNFs) in the geriatric population are a common injury with multiple treatment options. While elective total hip arthroplasty (THA) has been the gold standard for durability and functional outcome, this has only recently been proposed as a treatment options for FNFs in geriatric patients. Historically there have been concerns that acute THA for FNF has resulted in increased revision rates compared to elective THA. The primary outcome in this study was reoperation. Secondary outcome was 1-year mortality rate.

Methods: This was a retrospective review of patients between 1992 and 2014 from 5 hospitals. Inclusion criteria were age >50 years, with acute FNF treated with THA. Exclusion criteria were hemiarthoplasty and subacute or chronic FNF.

Results: 221 patients met criteria. The mean age was 73.8 years (±10.4), with 72% being female. 50.8% cases utilized a head size less than 36 mm, 48.2% used a head size of 36 mm or greater. One-year mortality rate was 6.3%. Overall revision rate was 6.8%. When recalled and failed metal on metal implants (MoM) were excluded, the revision rate dropped to 4.5. 70% of the revisions were performed in the first year. Average time to revision surgery was 19.9 months. 5-year survival free from revision was 96.3%, 10-year survival was 93%.

Conclusion: With modern implants and techniques the outcomes of THA for acute femoral neck fractures approaches the results reported for elective THA. This has important implications as reimbursement for hip arthroplasty transitions to bundled payments.

Figure 1: Survival Free From Revision for Acute THA After Femoral Neck Fractures



See pages 401 - 442 for financial disclosure information.

Factors for Increased Hospital Stay and Utilization of Post-Acute Care Facilities in Geriatric Orthopaedic Fracture Patients

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Purpose: The treatment of geriatric fractures requires a considerable amount of both hospital and post-acute care resources. This study aims to determine the extent of utilization of health-care resources in the geriatric fracture population and to identify factors associated with burden on resources.

Methods: This is a retrospective study of 1074 patients ≥65 years admitted to an orthopaedic service for a long bone fracture between July 2014 and June 2015. Outcomes were hospital length of stay (LOS), discharge disposition, and post-acute care facility LOS. Secondarily, readmission rates and mortality were assessed. Multivariable regression analyses were performed to identify factors associated with utilization.

Results: Prior to injury, 96% of patients lived at home and 50% ambulated independently. Median hospital LOS was 5 days (interquartile range [IQR], 3-7). 878 patients were discharged to a rehabilitation facility, with 45% being discharged <20 days. 10% of patients (n = 108) were readmitted <90 days of their discharge. 924 patients were still alive 1 year after the injury. Higher Charlson Comorbidity Index (CCI) (P = 0.048), male sex (P <0.001), preinjury use of an ambulatory device (P = 0.006), and undergoing surgical treatment (P <0.001) were associated with longer hospital LOS, low-energy mechanism of injury (P = 0.001) and having a fracture of the upper extremity (P = 0.001) were associated with shorter LOS. An upper extremity fracture was associated with an increased odds ratio (OR) of being discharged home (OR 10.2, 95% confidence interval [CI] 5.7-18.2; P <0.001), older age (P <0.001), preinjury ambulatory device (P = 0.001), and surgery (P = 0.012) were risk factors for requiring discharge to another inpatient facility. Older age (P <0.001), preinjury ambulatory aid (P <0.001), and preexisting immobility (P <0.001) were independent risk factors for LOS >20 days in a rehabilitation facility. Discharge home was not found to be associated with an increase in 1-year mortality after adjusting for age, CCI, sex, fracture location, and surgery (P = 0.727). Shorter LOS in rehabilitation facilities (<20 days) was also not associated with an increase in 1-year mortality (P = 0.520).

Conclusion: Elderly orthopaedic fracture patients utilize a significant amount of post-acute care resources and age, CCI, surgery, fracture location, preinjury ambulatory status, and preinjury living status were found to be associated with the use of these resources.

Maturation of a Comprehensive Multidisciplinary Geriatric Hip Fracture Program Affects In-Hospital Outcomes but not 1-Year Mortality

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Purpose: Our institution has attempted to improve outcomes for geriatric hip fracture patients by instituting a comprehensive multidisciplinary hip fracture program. We previously reported outcomes before, during, and soon after implementation; that study showed that a learning curve existed. Our patients' outcomes including length of stay (LOS) and in-hospital mortality (IHM) deteriorated during implementation of the program. As the program has now matured, we reviewed the net effect on patient outcomes for the 5 years since implementation. The goal of this study was to evaluate the sustained effects of our geriatric hip fracture program on patients' clinical outcomes.

Methods: This is a retrospective study of consecutive geriatric hip fracture patients treated at a busy metropolitan community hospital. A large contemporary study cohort of patients treated after program maturation (May 2011 to Dec 2012) was studied and compared to outcomes previously reported. Patients aged 60 years of age and older with operatively treated low-energy proximal femur fractures were included. Patients underwent workup and fixation of their hip fracture per protocol; demographic and clinical outcome data were recorded. Outcome measures include LOS, IHM, and 1-year mortality. Statistical analysis was performed using ×2 and analysis of variance testing.

Results: A total of 1268 patients treated in our hip fracture program were studied, 611 treated since the program had matured. These were compared to 211, 212, and 234 patients in the before, during, and soon after implementation cohorts. Demographic and treatment data were similar between study groups. Once established, average LOS was 6 days, significantly shorter than the 7.4, 6.7, and 6.5 day LOS of the prior cohorts ($P < 0.001$). In-hospital mortality after the program's maturation was 1.8%, lower than the previously reported mortality during (5.1%) and early after (3.0%) the start of the program ($P < 0.01$). However, 1-year mortality remained similar through all study periods at 25%, 25%, 20%, and 24.5%, respectively.

Conclusion: Significant improvements in hospital outcome measures, including LOS and IHM, was seen with maturation of our comprehensive, multidisciplinary hip fracture program. This follows up our previous work that showed notably poorer outcomes during and shortly after implementation of a hip fracture program, ie, a learning curve. A well-established comprehensive geriatric hip fracture program improves hospital-based patient outcomes but does not affect 1-year mortality.

See pages 401 - 442 for financial disclosure information.

Nationwide Analysis of Femoral Neck Fractures in Elderly Patients: A Receding Tide

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Purpose: Geriatric femoral neck fractures are associated with significant morbidity and medical cost. We evaluated incidence and management trends of femoral neck fractures over the past decade in the United States.

Methods: Patient data from 2003 through 2013 were obtained from the Nationwide Inpatient Sample database. Femoral neck fractures in patients ≥65 years of age were identified and grouped using ICD-9 procedure codes of internal fixation, hemiarthroplasty, or total hip arthroplasty. The nationwide incidence of femoral neck fractures was calculated and presented as an age-adjusted population rate. Bivariate methods were used for trend analysis and comparisons between groups. Logistic regression modeling was used to identify complications.

Results: From 2003 to 2013, we identified 808,941 femoral neck fractures in patients 65 years and older. The national age-adjusted incidence of femoral neck fractures decreased from 242 per 100,000 US adults in 2003 to 146 in 2013. The proportion of fractures managed operatively with total hip arthroplasty (THA) increased over time (5.9% in 2003 vs 7.4% in 2013, P <0.001). Concurrently, the use of hemiarthroplasty (HA) declined (65.1% vs 63.6%, P <0.001). In 2013, the median age of patients treated with THA was significantly younger (77.3 years) compared to HA and open reduction and internal fixation (ORIF) (83.2 and 82.0). The THA group had significantly higher median initial hospital costs ($18,265) compared to the HA and ORIF groups ($15,786 and $11,177). THA utilization rates were higher in urban teaching hospitals (8.2% vs 6.9%) and large hospitals (7.6% vs 7.1%). In the multivariable logistic regression model, transfusions were more likely to occur in THA patients compared to HA (odds ratio [OR] 1.4, 95% confidence interval [CI] 1.2-1.6, P = 0.001) and ORIF (OR 3.2, 95% CI 2.7-3.9, P <0.001).

Conclusion: In the last decade, the total number and population rate of femoral neck fractures in the elderly declined significantly. There was a modest but significant increase in the utilization of THA. THA is associated with significantly higher initial hospital costs and incidence of transfusions when compared to ORIF and HA.

Low-Dose Lithium Regimen Significantly Augments Rodent Osteoporotic Bone Fracture Healing

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Purpose: Osteoporotic bone fractures are highly prevalent and involve lengthy recovery. Lithium is a known anabolic agent for bone that inhibits glycogen synthase kinase-3β in the Wnt/β-catenin pathway, leading to upregulation of osteogenesis. Recently, we demonstrated that optimized lithium regimen (20 mg/kg LiCl from 7 days post fracture for 14 days) improve femoral fracture healing in healthy rats (46% higher torsional strength at 4 weeks). This study assessed lithium therapy to improve fracture healing in osteoporotic bone.

Methods: Three-month-old female Sprague Dawley rats were bilaterally ovariectomized and housed for 3 months to establish osteoporotic phenotype. Closed diaphyseal fractures were created in prestabilized femurs using a load drop apparatus. The optimal regimen for healthy rats (day 7 onset, 20 mg/kg oral dose, and 14 days duration) was evaluated against saline (control) treatment, with femurs harvested at 4 weeks. A second set of rats under a regimen with day 10 onset at the same dose and duration was evaluated with femurs harvested at 6 weeks. Femurs were μCT scanned at 14.8 μm voxels and destructively tested under torsion. Maximum yield torque was the primary outcome measure. Student t tests were used to determine differences between the treatment groups and their respective controls. Pearson correlation analysis was performed between stereologic and biomechanical strength measures.

Results: Of the 49 fractured rats, 37 with fragmentary diaphyseal fractures were included. Onset at day 10 led to 50% higher maximum yield torque at 6 weeks (309 vs 206 N-mm, P=0.005; n=7,7). Treatment onset at day 7 suggested a trend toward a modest 13% improvement in maximum yield torque evaluated at 4 weeks (234 vs 206 N-mm, P=0.10; n=10,13). In paired comparisons of stereologic parameters to controls, the day 10 onset lithium group had lower bone volume (63 vs 78 mm^3, P=0.01), bone volume/total volume (BV/TV) (19 vs 24 %, P=0.02), bone mineral density (BMD) (169 vs 230 $mgHA/cm^3$, P=0.04), and bone mineral content (51 vs 74 mgHA, P=0.03). For the day 10 onset regimen, torsional stiffness negatively correlated with callus BV/TV (r=-0.58, P=0.03) and callus BMD (r=-0.61, P=0.02).

Conclusion: This is the first study to demonstrate the positive effect of lithium administration on osteoporotic bone fracture healing. The proposed low-dose, 10-day onset treatment is a safe and translatable regimen providing guidelines for clinical evaluation of lithium toward enhancing fracture healing in osteoporotic patients.

See pages 401 - 442 for financial disclosure information.

Stratification of 1-Year Functional Outcome and Mortality in a Cohort of Geriatric Trauma Patients: The Power of STTGMA

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Purpose: It is well established that elderly trauma patients are at increased risk of poor long-term functional outcome compared to their younger counterparts. In this study, we sought to determine if a novel inpatient mortality risk assessment tool designed to be calculated at the time of admission predicts patient-reported functional outcomes and mortality at 1 year.

Methods: From October 1, 2014 to September 30, 2015, 685 patients >55 years old who were orthopaedic surgery consults or trauma surgery consults were enrolled in a prospective database. On initial evaluation, each patient's demographics, injury severity, and functional status were utilized to calculate a trauma triage score (STTGMA, or Score for Trauma Triage in the Geriatric and Middle-Aged Orthopaedic Trauma Patient). Patients were contacted at 1 year to complete an EQ-5D questionnaire and report their percent return to baseline function. Higher EQ-5D index scores denote better function. Patients were stratified into minimal, low, moderate, and high-risk cohort groups based on inpatient mortality risk of <1.1% (145 patients), 1.1-4% (83 patients), 4-50% (48 patients), >50% (16 patients).

Results: 247 patients (36.1%) were successfully contacted at 12-month follow-up. 45 (6.6%) patients had died within the year following index hospitalization. There was no observed difference between patients who were successfully contacted and those who were lost to follow-up. The mean STTGMA score was 2.6 ± 6.2%. Patients reported on average a 76.4 ± 27.5% return to baseline function with 43% of patients reporting that they were back to their baseline level of function. Minimal risk patients had significantly higher 1-year EQ-5D index scores (0.79 ± 0.20, 0.67 ± 0.32, 0.60 ± 0.30; P<0.0001) for minimal, low, and moderate risk patients, respectively. There was also a significant difference in percent return to baseline functioning (80.1 ± 25.2% for minimal risk, 73.7 ± 29.5% for low risk, and 62.7 ± 31.9% for moderate risk; P = 0.009). The Kaplan-Meier curve shows that high risk patients had pronounced decreased survival within the initial days after discharge compared to other cohorts.

Conclusion: This study demonstrates that patients identified with the STTGMA tool as having an increased risk of inpatient mortality following trauma correlate with poorer functional outcomes at 1 year. The STTGMA risk score is also a valuable tool to predict mortality up to 1 year following discharge. The ability to assess long-term function and mortality prior to inpatient admission allows for an informed discussion with patient and family regarding expected long-term recovery and goals of care.

Topical Tranexamic Acid and Blood Loss Complications in Femoral Neck Fractures Treated with Hemiarthroplasty

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Purpose: Tranexamic acid (TXA) has been successfully utilized in many areas of medicine. Its use in orthopaedics, particularly traumatic fracture care, is evolving. Our goal was to determine if treatment with topical TXA for geriatric femoral neck fractures treated with hemiarthroplasty resulted in decreased postoperative complications associated with acute blood loss during hospitalization and any thromboembolic event within 6 months following surgery.

Methods: Consecutive patients over age 65 years operated for hip hemiarthroplasty following femoral neck fracture of nonpathologic origin were studied. TXA was used per surgeon preference. Pre- and postoperative laboratory tests were performed according to standard practice. All data extraction occurred via chart review. Postoperative complications of interest included hematoma formation, blood transfusion, reoperation, deep vein thrombosis, myocardial infarction, pulmonary embolism, and cerebrovascular accident.

Results: 84 patients (63 nonTXA and 21 TXA), matched 3:1 by gender and age ± 2 years, were included in analysis. Average age was 83.7 years (36 males, 48 females). There were no significant differences in the mean postoperative day 1 hemoglobin or hematocrit between groups. However, there were significant differences in transfusion rates ($P = 0.017$) as well as lowest hemoglobin (10.3 vs 9.2, $P = 0.011$) and hematocrit (32.6 vs 28.5, $P = 0.003$) values during hospitalization. This difference resulted in 14 transfusions in the the nonTXA group (22% of patients, average 1.5 units of blood required, range 1-3) and zero transfusions in the TXA group. None of the TXA patients experienced a postoperative thromboembolic event and 1 nonTXA patient suffered a cardiac arrest within 3 months of hemiarthroplasty. There were no patients in either group who developed postoperative bleeding-related complications.

Conclusion: In our series, hemiarthroplasty treated with intraoperative topical TXA resulted in zero postoperative blood transfusions, higher overall postoperative hemoglobin and hematocrit levels, and no rehospitalization for bleeding-related complications.

See pages 401 - 442 for financial disclosure information.

Long-Term Outcome and Reoperation Rates After ORIF of Distal Femoral Fractures in Patients Older than 60 Years

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Purpose: Distal femoral fractures in patients older than 60 years are challenging fractures to treat and several authors have proposed distal femoral replacement as a primary treatment option for management of these injuries. Our hypothesis is that patients over age 60 with distal femoral fractures have long-term outcome scores after open reduction and internal fixation (ORIF) that are acceptable in comparison to knee arthroplasty outcomes and have an overall low conversion rate to total knee arthroplasty.

Methods: A retrospective review of a prospectively collected billing database was conducted for all patients who underwent ORIF of an acute distal femur fracture and were also over 60 years of age at a single Level I urban trauma center. The study period was 2007 to 2015, and only patients who had healed or had at least 12 months of follow-up were included. The hospital records were reviewed and then all study patients were called by telephone using a standardized script. Our primary outcome measure was the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score as it has well established comparative values in knee arthroplasty literature. Our secondary outcome was the occurrence of any secondary surgeries. The study group consisted of 116 patients of whom 68 were able to be reached for WOMAC score evaluation. The average age was 71.1 years (range, 60.4 -91.6), 78% were female, and 50% were periprosthetic fractures around a prior arthroplasty. Average follow-up was 3.2 years.

Results: The average WOMAC score for the 68 patients who could be contacted was surprisingly good at 22.3 (95% confidence interval [CI]: 19.2 to 25.1; pain 5.98, stiffness 3.26, function 13.02). Overall WOMAC scores did not differ based on whether the fracture was periprosthetic (24.1) or non-periprosthetic (20.4, P = 0.26 Student t test). Of note, 22 (32.3%) of the original cohort of 68 patients required return to the operating room for the treatment of a complication related to their fracture treatment. Reasons for repeat surgery included nonunion (16.2%, 11 of 68), deep wound infection requiring return to the operating room (4.4%, 3 of 68), and symptomatic hardware removal (10.3%, 7 of 68). Only 2.9% (1 of 34) of the patients with native knees were converted to total knee arthroplasty (TKA) during the follow-up period.

Conclusion: In patients over 60 years of age with ORIF of a distal femur fracture, conversion to TKA was rare and WOMAC scores are surprisingly good. Our study is the first to report WOMAC functional scores of these patients and these scores are comparable to those found in most series of patients who have had a TKA for osteoarthritis (typical WOMAC near 20). However, nonunion rates continue to be high as to overall need to return to the operating room for prominent implant removal or infection.

MRI-Only Occult Geriatric Hip Fractures: Is Displacement Common with Nonoperative Treatment?

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Purpose: Geriatric fractures of the proximal femur are common and typically warrant surgical stabilization to allow patient mobilization and prevent displacement. This treatment algorithm is commonly extended to include hip fractures that are not evident on orthogonal radiographs or CT, but display increased edema within the femoral neck or intertrochanteric regions with MRI. However, it is not known how often these fractures displace when treated nonoperatively. The purpose of our study was to report the rate of displacement requiring secondary surgery in nonoperatively treated occult geriatric hip fractures.

Methods: All nonoperatively treated femoral neck or intertrochanteric femur fractures (AO/OTA 31A and 31B) at our institution from 2003 to 2016 were initially identified using an institutional geriatric hip fracture database and closed treatment CPT code search. Patients older than 65 years of age with no fracture on orthogonal radiographs or CT but increased osseous edema on MRI consistent with an occult fracture were included. Patients who died prior to evidence of fracture displacement or radiographic and clinical evidence of healing were excluded. All charts and radiographs were reviewed for demographic data, treatment course, and radiographic or clinical evidence of fracture healing. The primary outcome measure was fracture displacement necessitating surgery.

Results: Fourteen patients met the inclusion criteria and three were subsequently excluded due to death. Of the remaining 11 patients, there were six femoral neck fractures and five intertrochanteric fractures. Treatment typically consisted of restricted weight bearing and gradual mobilization. Of the entire cohort, two fractures displaced necessitating surgery (2/11; 18.2%). One of the displacements occurred after the patient's MRI was read as negative, and he had received no weight bearing restrictions. Both of the displaced fractures occurred in the femoral neck cohort (2/6; 33%) compared to none in the intertrochanteric group (0/5; 0%). This difference was not significantly significant (p=0.45).

Conclusion: Two out of eleven (18%) occult hip fractures displaced necessitating surgery. Both displacements occurred in the femoral neck group. Our study represents the largest investigation detailing the natural history of nonoperatively treated occult geriatric hip fractures. However, no definitive treatment recommendations can be made due to our small cohort size, therefore we recommend that surgeons continue to manage occult hip fractures using their preferred treatment algorithm.

See pages 401 - 442 for financial disclosure information.

Increased Mortality with Delayed Surgery for Medically Fit Hip Fracture Patients

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Purpose: Empirical evidence points to the benefits of early surgery, while some health services research fails to associate delayed surgery and death as the "reason for delay" is unknown. Capitalizing on the availability of the reason for delay data, in a prospective cohort, we aimed to identify the risk of death with delay of surgery for patients who are otherwise fit.

Methods: Prospective data from hip fracture patients operated between June 2013 and October 2016 in 22 hospitals included: baseline information, preoperative data (including reason for delay at 24 + 48 hours), postoperative process, and outcome measures (including complications and death). Univariate regression analysis was reported as odd ratios and confidence intervals.

Results: There were 7188 patients, mean age 83 years. 90% of patients received surgery within 48 hour of first admission to a hospital (72%-95%). Regression analysis focusing on in-hospital mortality as an outcome identified a "protective association" from death with younger age, women, and patients mobilized on preoperative day (POD) 1. In contrast, surgery after 48 hours for all patients (patients delayed because of fitness and because of administrative reasons) was associated with an approximate 63% increased risk of death, dropping slightly to 60% for patients who were delayed for administrative reason alone.

Conclusion: Analysis of prospectively collected perioperative information on a large cohort identifies factors associated with risk of in-hospital mortality. Univariate regression showed a 65% decreased risk of death through mobilization on POD 1 with a 60% increased risk of death when medically fit patients are delayed for administrative reasons.

Odds Ratio Estimates				
Effect	**Point Estimate**	**95% Wald Confidence Limits**		
Surg >48	1.626	1.174	2.252	~60% increased risk of death with delay>48
agegr 60s vs 90s	0.104	0.050	0.215	Younger = lower risk
agegr 70s vs 90s	0.225	0.147	0.345	Younger = lower risk
agegr 80s vs 90s	0.474	0.369	0.610	Younger = lower risk
Sex (f)	0.576	0.451	0.736	Women = lower risk
preadmit_home	0.951	0.742	1.220	Preadmit Living arr = ns
mob_1	0.359	0.280	0.460	MOB POD_1 = lower risk
w_e	0.984	0.759	1.275	Weekend = ns
Effect	**Point Estimate**	**95% Wald Confidence Limits**		
adminOR_48	1.597	0.958	2.660	~60% increased risk of death when delay = admin at 48h

Use of a Novel Telescoping Multiple Screw Plate for Treatment of Intertrochanteric Hip Fractures

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Purpose: A new implant, with multiple smaller diameter cancellous screws that slide in a barrel and lock to a side plate, has shown promising potential for managing femoral neck fractures in Europe. We report the early results using a novel design telescoping screw plate in a consecutive series of patients who sustained an intertrochanteric fracture in the US.

Methods: After IRB approval, a retrospective study was performed on consecutive patients who sustained an intertrochanteric fracture and were treated with the Telescoping Screw Plate at our institution from April 2015 until April 2016. The Telescoping Screw Plate consists of three 7.5-mm cancellous lag screws that telescope within a barrel that locks to a side plate. The 3 screws are oriented in an inverted triangular configuration at a 130° angle to the sideplate. The screw sliding occurs solely within the barrel, so that protrusion of the screws into the lateral soft tissue is prevented. Patients were followed at 6 weeks, and 3, 6, and 12 months. Radiographs were assessed for signs of healing, osteonecrosis, loss of fixation, implant failure, and fracture of the lateral wall. Amount of screw sliding and femoral medialization were determined at latest follow-up. Bone lengths were obtained on patients at 6 or 12 months.

Results: 64 patients who sustained an intertrochanteric fracture were treated. 42 fractures were stable (OTA type 31A1) while 22 were unstable intertrochanteric fractures (OTA type 31A2). 44 patients (69%) were available for 6-month minimum follow-up (mean 9.0 months; range, 6-18). No patient sustained loss of fixation, lag screw cutout, nonunion, or osteonecrosis. No fracture sustained a fracture of the lateral wall. Overall, lag screw slide averaged 4.0 mm (range, 0-17 mm). In stable fractures, lag screw slide averaged 1.2 mm (range, 0-8) and in unstable fractures averaged 8.8 mm (range, 0-17). Femoral medialization ranged from 0-10%. Bone length radiographs were available in 21 patients (16 stable fractures, 5 unstable fractures). Overall, femoral shortening averaged 4.1 mm (range, 0-19). In stable fractures, femoral shortening averaged 1.1 mm (range, 0-9) and in unstable fractures averaged 11.2 mm (range, 0-19).

Conclusion: Our results using the Telescoping Screw Plate are promising with very high union rates and low complication rates when used to stabilize both stable and unstable intertrochanteric fractures. The amount of screw sliding and limb shortening were much lower than those reported with use of a conventional sliding hip screw and were comparable to those reported using an intramedullary device.

See pages 401 - 442 for financial disclosure information.

Use of a Novel Telescoping Multiple Screw Plate for Treatment of Femoral Neck Fractures

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Purpose: A new implant, with multiple smaller diameter cancellous screws that slide in a barrel and lock to a side plate, has shown promising potential for managing femoral neck fractures in Europe. This implant is a hybrid between cancellous lag screws and a sliding hip screw, providing rotational stability, controlled collapse of the femoral neck, and prevention of screw toggling within the femoral neck. We report the results using a newer design telescoping screw plate in a consecutive series of patients who sustained a femoral neck fracture in the US.

Methods: After IRB approval, a retrospective evaluation was performed on consecutive patients who sustained a femoral neck fracture and were treated with the Telescoping Screw Plate at our institution from April 2015 until April 2016. The Telescoping Screw Plate consists of three 7.5-mm cancellous lag screws that telescope within a barrel that locks to a side plate. The 3 titanium screws are oriented in an inverted triangular configuration at a 130° angle to the side plate. The screw sliding occurs solely within the barrel, so that protrusion of the screws into the lateral soft tissue is prevented. The side plate is available in 2 and 4-hole lengths and has anterior offset of the proximal telescoping screw cluster for an anatomic fit. Patients were allowed to weight-bear as tolerated after surgery using an assistive device as needed.

Results: 44 patients who sustained a femoral neck were treated, 15 men and 29 women with an average age of 70 years. 23 fractures were nondisplaced or valgus impacted while 21 were displaced femoral neck fractures. 8 patients (18%) were lost to follow-up (6 nondisplaced, 2 displaced fractures) leaving 36 patients (82%) who had 6-month minimum follow-up (range, 6-16 months). In the nondisplaced fracture group (n = 17), all fractures united with no loss of fixation or osteonecrosis. In the displaced fracture group (n = 19), 18 fractures united (95%) while 1 patient had loss of fixation with screw cutout at 1-month follow-up.

Conclusion: Our early results using the Telescoping Screw Plate are promising, with very high union rates and low complication rates.

Time to Surgery Is Not a Predictor of 30-Day Postoperative Outcomes in Patients Undergoing Hip Fracture Surgery

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Purpose: There currently exists significant debate in the orthopaedic literature regarding the optimal timing of surgery for hip fractures. The goal of the present study is to evaluate the association between timing of surgery with outcomes and postoperative complications in patients with hip fractures.

Methods: 17,459 patients with surgically managed hip fractures between 2006-2013 were selected from the National Surgical Quality Improvement Program (NSQIP) database. Time to surgery was categorized based on the following criteria: surgery within 24 hours of admission, between 24-48 hours of admission, and >48 hours after admission. Univariate and multivariate analysis were used to examine the effect of time to surgery on 30-day outcomes including length of stay, readmission rates, reoperation rates, mortality rates, and complications. Complications were classified into major (acute renal failure, cardiac arrest, coma of duration >24 hours, deep wound infection, myocardial infarction, pulmonary embolism, peripheral nerve injury, prolonged intubation, reintubation, septic shock, sepsis, stroke) and minor (deep vein thrombosis, hardware failure, pneumonia, superficial surgical site infection, transfusion of blood products, urinary tract infection, wound disruption).

Results: Of the 17,459 patients, 4107 (23.5%) underwent surgery within 24 hours, 8740 (50.1%) within 24-48 hours, and 4,612 (26.4%) greater than 48 hours after hospital admission. Mean age of patients in these groups was 82.9, 83.3, and 83.4, respectively. Increased time to surgery was associated with longer lengths of hospital stays with a difference of 4.5 days between the less than 24-hour group and greater than 48-hour group ($P < 0.001$). Multivariate analysis did not identify time to surgery as an independent predictor of postoperative outcomes other than increased length of stay. Preoperative functional status and patient comorbidity burden were identified as important independent predictors of postoperative outcomes ($P < 0.001$).

Conclusion: While a delay in the management of hip fractures is associated with a significant increase in hospital length of stay, 30-day postoperative outcomes including reoperation, readmission, complication, and mortality were not adversely affected in patients undergoing surgery for a hip fracture. Maximally optimizing patients with significant comorbidities prior to surgery should not be neglected in order to decrease time to surgery.

See pages 401 - 442 for financial disclosure information.

Can Perioperative Computed Tomography Hounsfield Units Predict Failure of Femoral Neck Fracture Fixation?

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Purpose: Global hip fracture incidence in 2050 may reach 6 million. Failure after fixation occurs in 10-30%. The purpose of our study was to determine whether Hounsfield Units (HU) on perioperative CT, a surrogate for bone density, correlated with radiographic outcomes. We hypothesized that lower HU correlates with shortening, screw cutout, and revision surgery.

Methods: We performed a single-center retrospective review from 2004 to 2015 in patients with a femoral neck fracture and perioperative CT. We included 131 patients ≥18 years of age treated with closed/open reduction internal fixation with screws or a sliding hip screw. We recorded demographic data, fracture type, and associated injuries. We recorded 2 HU in PACS (picture archiving and communication system) software: an axial femoral head (AH) slice at the foveal level, and a middle coronal neck (CN) slice. We reviewed charts and imaging for outcomes: femoral neck shortening >5 mm, screw cutout, and revision surgery.

Results: At a mean 31 months follow-up, we measured significant shortening in 50 patients. Screw cutout occurred in 16, and 37 required revision surgery (including HWR [hardware failure], revision ORIF [open reduction and internal fixation], or arthroplasty). The shortening group had significantly lower HU in the AH and CN versus non-shortening (AH: 202 vs 249.3, P = 0.002; CN: 78.2 vs 131.7, P = 0.003). The cutout group had significantly lower HU in the AH and CN than non-cutout (AH: 174.3 vs 239.3, P = 0.018; CN: 56.8 vs 119, P = 0.013). Multivariate analysis revealed 16.58 odds ratio (OR) of cutout with AH HU <146.06 (4.30-73.73), P = 0.001; CN OR 5.80, P = NS. The OR of shortening was 6.59 with CN HU <141.42 (1.99-26.80), P = 0.019; AH OR 2.90, P = NS. The OR of any shortening, revision, or cutout was 6.37 with CN HU <150.65 (2.20-20.61), P = 0.006; AH OR 2.24, P = NS. The non-shortening group had a younger mean age than shortening (53.2 vs 66.0, P = 0.006). Fixation device showed no difference. Displaced fractures shortened more often than nondisplaced (52% vs 48%, P = 0.046). No significance was seen for revision surgery or a composite outcome.

Conclusion: Our study revealed significant outcome differences for screw cutout and femoral neck shortening related to lower HU in the femoral head and neck. Logically, screw cutout more closely correlates to femoral head density, while shortening correlates with femoral neck density. HU measurement can aid surgical decision making regarding fixation or arthroplasty. Additional research is needed to better define clinical guidelines.

How Should Medicare's "Surgical Hip and Femur Fracture Treatment" Bundled Payment Program be Risk-Adjusted?

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Purpose: Bundled payments for orthopaedic procedures are becoming more popular as a means to reduce costs and improve quality and care coordination. The latest Medicare bundling program covers Surgical Hip and Femur Fracture Treatment (SHFFT), without a finalized start date. Critics note that bundled payments without appropriate risk adjustment may be inequitable to providers and restrict access to care for certain patient populations. Still, the SHFFT program only includes plans for rudimentary risk stratification using Diagnosis-Related Group (DRG) codes. The goal of this study was to identify and quantify patient factors that could improve risk adjustment for SHFFT bundled payments. We hypothesize that the current proposal will insufficiently account for comorbidities, thereby underestimating appropriate reimbursement for certain patients.

Methods: A 5% random sample of Medicare patients spanning 2008-2012 was queried, and 27,898 patients were identified who met SHFFT inclusion criteria (DRG 480, 481, or 482). Reimbursement was determined for each patient over the bundle period (the surgical hospitalization and 90 days of post-discharge care). Multivariable regression was performed to test demographic factors, comorbidities, geography, and specific types of surgery for associations with reimbursement.

Results: Average reimbursement was $23,632 ± 17,586. Male gender was associated with $1186 ± 228 higher reimbursement (P <0.001). Younger patients also tended to earn higher payments; eg, those aged 65-69 years were reimbursed $2282 ± 389 more than those over age 85 (P <0.005). Most comorbidities were associated with higher reimbursement, but dementia was associated with $2354 ± 243 lower payments (P <0.005). 22 procedure codes are included in the bundle, and patients undergoing the most common surgeries (nail or screw fixation) accounted for 98% of cases and were reimbursed similarly. However, other procedures varied enormously in average reimbursement (up to $18,000, P <0.005). DRG codes also showed significant differences in reimbursement (P <0.005); eg, DRG 482 was reimbursed $10,421 ± 543 more than DRG 480. Payments varied significantly by state (P ≤0.016). Risk adjustment for individual comorbidities performed better than DRG alone (R squared = 0.22 vs 0.15).

Conclusion: Our results suggest that SHFFT bundled payments should use more robust risk-adjustment techniques to ensure providers and hospitals are reimbursed fairly and patients retain adequate access to care. At a minimum, payments should be adjusted for comorbidities, demographic factors, geography, and surgery type.

See pages 401 - 442 for financial disclosure information.

Early Surgery for Proximal Femoral Fractures Is Associated with Lower Mortality: Report of 12,654 Patients

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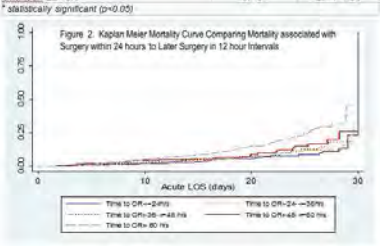
Purpose: Hip fracture is a common injury with associated high mortality. Early operative treatment remains a contentious issue as some studies show no clear advantage to early surgery. The purpose of this study was to compare the hazard for mortality in patients who had operative treatment for proximal femoral fractures within 48 hours of presentation to the emergency department and those who did not. We hypothesized that mortality would be significantly higher in those with delayed time to the operating room.

Methods: This was a retrospective study using administrative data on all patients who underwent operative treatment for proximal femoral fractures between April 2009 to 2013. Time from presentation to emergency department to the operating room (OR) was calculated in hours using the National Ambulatory Care and Discharge Abstract Databases. In-hospital mortality to 30 days post fracture was determined using the Discharge Abstract Database. The primary outcome was the in-hospital mortality rate; hospital stay was truncated at 30 days postoperatively. Cox regression analysis was used to assess whether timing of surgery had an effect on mortality after controlling for age, gender, and comorbidity (using the Charlson Comorbidity index). Proportional hazards for mortality using ≤48 hours (reference category) versus >48 hours to OR after controlling for age, sex, and comorbidity (Charlson Comorbidity Index). Proportional hazards for mortality using ≤24 hours (reference category), >24-36 hours, >36-48 hours, >48-60 hours, and >60 hours to OR after controlling for age, sex, comorbidity (Charlson Comorbidity Index).

Results: Of the 12,654 patients admitted with hip fracture during the study time period, 8503 (67.3%) were female and the average age was 77.2 ± 14.5 years. Almost half (5960 [47.1%]) had a Charlson Comorbidity Score of at least 1. Overall 380 (3.7%) patients died in hospital. Of the overall cohort, 4676 (37%) received surgery within 24 hours, 2833 (22.4%) had surgery between 24 and 36 hours, 2959 (17.3%) had surgery between 36 and 48 hours, and 2959 (23.4%) had surgery after 48 hours of admission. After adjusting for age, sex, and comorbidity, those patients who went to the OR at >48 hours post fracture were significantly more likely to die in hospital than those who received surgery within 48 hours (hazard ratio 1.60; 95% confidence interval 1.33, 1.92)

Impact of Time to OR on Mortality using 12 hour Time Intervals	Hazard Ratio	95% CI
Time to OR (>24-36hrs vs ≤24 hrs)	1.01	0.76-1.33
Time to OR (>36-48hrs vs ≤24 hrs)	1.12	0.84-1.50
Time to OR (>48-60hrs vs ≤24 hrs)	**1.35***	**1.01-1.80**
Time to OR (>60 hrs vs ≤24 hrs)	**1.80***	**1.40-2.32**
Age	1.07*	1.05-1.08
Male vs. Female	1.65*	1.36-1.99
Charlson 1 vs.0	1.77*	1.35-2.32
Charlson ≥2 vs.0	3.43*	2.71-4.35

* statistically significant (p<0.05)



Conclusion: The results from this large cohort encompassing all patients with hip fracture treated from 2009-2013 demonstrate that delay in surgery by more than 48 hours has an adverse effect on in-hospital mortality. Patients presenting with proximal femoral fractures should be adequately resuscitated, medically optimized, and prioritized to undergo surgery on the next available trauma list.

Does Increasing Fracture Comminution Affect Version After Intramedullary Nailing of Femoral Shaft Fractures?

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Purpose: Intramedullary (IM) nailing has become the standard of care for the treatment of most femoral shaft fractures. Complications in fracture healing such as malrotation and malreduction may be a consequence of the energy imparted on the femur and subsequently the degree of comminution of the fracture. The objective of this study was to analyze the relationship between the degree of comminution and the ability to obtain acceptable femoral version following IM nailing of femoral shaft fractures.

Methods: Between 2000 and 2009, 417 consecutive patients with femur fractures were treated with an IM nail at a Level I trauma and tertiary referral center. Of these patients, 307 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 and reviewed by a musculoskeletally trained radiologist and the senior, trauma fellowship-trained orthopaedic surgeon.

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 had no significant impact on obtaining acceptable femoral version following IM nailing. Controlling for several factors via univariate and multivariate models yielded similar results. With current nailing systems and techniques taught and studied in the US, appropriate DFV can be obtained even in the most highly comminuted fracture patterns.

See pages 401 - 442 for financial disclosure information.

Open Proximal Femur Fractures From Ballistic Injuries Treated with an Antegrade Intramedullary Nail: The Ominous Sign of a Vascular Injury

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Purpose: Gunshot injuries to the proximal femur create uncommon fracture patterns. These injuries often present with significant comminution and soft-tissue damage, including vascular injury. As a result, they can be difficult to treat. While many studies discuss early management and outcomes of gunshot injuries to the femoral diaphysis, there is limited data evaluating the treatment of these injuries in the proximal femur. The anatomy of the proximal femur differs from the diaphysis as it consists of metaphyseal bone along with a wider medullary canal. This makes treatment with an intramedullary device more difficult, especially in the face of comminution. The aim of this study is to report clinical outcomes of a cohort of patients with open proximal femur fractures associated with gunshot injuries treated with an antegrade intramedullary nail.

Methods: A retrospective medical record review was performed of all patients with gunshot wounds and associated proximal femur fractures (AO/OTA-31/32 fracture within 5 cm of lesser trochanter) treated at our Level I trauma center with an antegrade intramedullary nail from 2008 to 2016. Patients were included if they had appropriate follow-up to determine union or if a secondary surgery was performed to address nonunion. Outcome measures included fracture union, nonunion, malalignment, vascular injury, infection, and reoperation.

Results: 57 patients met our inclusion criteria with 29 (mean age of 35 years) having appropriate clinical follow-up to determine union (average of 10 months). Using the AO/OTA classification, there were 2 (7%) 31-A3.2, 10 (34%) 31-A3.3, 5 (17%) 32-A3.1, 4 (14%) 32-B3.1, and 8 (28%) 32-C3.1 fractures. Union was achieved in 93% of the patients as determined by painless weight bearing and bridging callus on orthogonal radiographs. Malalignment (>5° of angulation in any plane) was present in 14%. Vascular injury requiring surgical treatment occurred in 4 patients (14%). The overall infection rate of the cohort was 14% with 75% of the infected patients having vascular injuries (P = 0.004). Two patients were found to have infected nonunions and both (100%) had associated vascular injuries.

Conclusion: Open proximal femur fractures associated with ballistic injuries can be treated successfully with antegrade intramedullary nail fixation. However, patients with vascular injuries that require repair are at increased risk for infection and nonunion.

Success of Bundled Payment Initiative in Hip Fracture Patients in Comprehensive Care for Joint Replacement Model

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Purpose: With the inclusion of hip fracture patients into the Comprehensive Care for Joint Replacement (CJR) payment model, analysis of these patients is warranted as they are higher risk than elective arthroplasty patients. The purpose of this study was to analyze the effectiveness of an initiative (designed for the Bundled Payments for Care Improvement [BPCI] program) for hip fracture patients included in the CJR model with respect to improving patient outcomes and reducing cost.

Methods: Patients discharged with the diagnosis-related group codes 469-470 performed for hip fractures from one academic medical center between January 2015 and December 2016 were evaluated. A BPCI initiative focused on optimizing care coordination/patient education/expectations and minimizing post-acute facility and resource utilization was initiated in January 2016. Patient length of stay, location of discharge, and readmission within 90 days were recorded. Medicare reimbursement claims data for the 90-day episode of care were collected and compared pre- and post-initiative. Patient outcomes prior to the introduction of the BPCI initiative were compared to those who participated in the initiative using a P value of <0.05 as significant.

Results: During this period, 108 hip fracture patients underwent arthroplasty procedures. 43 patients received care prior to initiative, and 65 patients participated in the initiative. There was no decrease in length of stay; however, the percentage of patients discharged home increased with the introduction of the BPCI initiative (14.0% vs 24.6%). There was also a 22.3% reduction in total 90-day episode of care costs ($55,648 vs $43,259) (costs as reimbursed by Medicare) upon introduction of the initiative. This change in mean cost is largely from the decrease in spending on skilled nursing facilities and acute rehabilitation facilities and an increase in spending on home health aides. There was no significant difference in readmission rate between the 2 cohorts.

Conclusion: Unlike elective joint replacements, there is little chance to optimize orthopaedic trauma patients presenting with hip fractures before surgery. As such, with the introduction of these patients into the CJR model, initiatives to provide resource conscious yet high-quality care to these patients is imperative. This study shows the success of one such program aimed at care coordination and minimizing post-acute hospitalization facility care both with respect to improved patient outcomes and substantial cost reduction.

See pages 401 - 442 for financial disclosure information.

Precise Lag Screw Placement with the Use of a Novel Computer-Assisted Surgery System During Cephalomedullary Nailing,

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Purpose: We hypothesized that utilizing a novel computer assisted surgery system (CASS) would allow for the precise placement of a lag screw in the femoral head during cephalomedullary nailing, while decreasing radiation and operative time.

Method: This study is a retrospective case-control study comparing the initial 123 cases that utilized this novel CASS to the previous 126 cases without the use of the CASS (conventional cases). Electronic chart review was performed to obtain the demographic information, fracture classification, and clinical outcomes. The tip-apex distance (TAD) for each case was measured postoperatively on PACS images, and the CASS TAD measurements were obtained from the case information saved on the CASS hard drive. The variables TAD, radiation time, operative time, and postoperative complications (cut-out, nonunion, mortality, removal painful implants, and deep infection) were evaluated for both groups. The groups were then subdivided into stable and unstable fractures, and the same demographics and variables were compared for all groups.

Results: The patients in this study represented a typical hip fracture population. Median age was 84 years. 66% were female and 34% were male. 73% were classified ASA class 3, severe systemic disease. All fractures were closed. Laterality was evenly split: 51% right and 49% left. The demographics of all groups were noted to be equivalent, with no significant differences detected ($P > 0.05$). The use of CASS in all cases resulted in a significantly better/lower TAD ($P < 0.001$) with significantly better precision/less variation ($P < 0.001$). These results are the same for the stable and unstable fracture groups ($P < 0.001$). The use of CASS resulted in a significantly shorter radiation time for all cases ($P = 0.003$) and for the stable fracture group ($P = 0.002$). No significant difference could be detected in the unstable fracture group ($P > 0.05$). The use of CASS in stable fractures resulted in significantly shorter operative time ($P = 0.039$). No significant difference could be detected when analyzing unstable fractures and all cases combined ($P > 0.05$). No significant difference was detected in the cut-out rate ($P > 0.05$), but the potential risk for a cut-out was higher in the conventional group (CASS group 95% CI: 0%-3.03%, whereas conventional group 95% CI: 0.44%-5.60%).

Conclusion: Precise lag screw placement during cephalomedullary nailing is possible with the use of the novel CASS. In addition, utilization of the CASS provides significant benefit by decreasing radiation time, operative time, and the potential risk of cut-out.

Extent and Morbidity of Trochanteric Fixation Nail Blade Lateralization

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Purpose: This study examined the incidence and risk factors associated with lateral helical blade migration and trochanteric pain in the commonly used trochanteric fixation nail (TFN).

Methods: A retrospective review was performed on 141 cases of pertrochanteric femur fractures treated with a TFN over 42 months at one Level I trauma center. Exclusion criteria included <60-day follow-up, preexisting osteonecrosis of the femoral head, or prophylactic TFN treatment. Patient demographics, operative findings, and radiographic findings were recorded. Medical records were reviewed to determine the presence of symptomatic hardware.

Results: Overall, 27 patients were symptomatic (19.1%), with 3 (2.1%) requiring revision surgery for blade prominence. 42 patients (29.8%) had >1 cm of lateralization, 16 of whom (38.1%) were symptomatic ($P < 0.02$). Risk factors for lateralization were AO classification, with 46.1% of A2 fractures lateralizing >1 cm. The quality of calcar reduction was nearly significant, with 44.8% of patients without an adequate reduction lateralizing >1 cm, compared with 26.4% with an adequate medial calcar reduction ($P = 0.054$). Lateralization >1 cm was directly associated with being symptomatic ($P < 0.001$) and having hardware removed for trochanteric pain ($P = 0.007$). Multivariate analysis revealed increasing tip apex distance, inadequate calcar reduction, and increasing fracture severity to all be predictive of excessive lateralization >1 cm.

Conclusion: This study demonstrates that nearly 20% of patients have lateral hip pain associated with cephalomedullary rodding. Final lateralization of the helical blade >1 cm was a very strong predictor of symptoms. Comminuted fractures tended to have more frequent problems although careful attention to calcar reduction may be protective. Attention to accurate blade placement within the femoral head should also be closely scrutinized. Surgeons should caution patients about this relatively frequent, likely underreported complication during preoperative counseling.

See pages 401 - 442 for financial disclosure information.

The Difference in Risk of Peri-Implant Fracture Utilizing Long Versus Short Cephalomedullary Nailing for Geriatric Patients with Intertrochanteric Femur Fractures

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Purpose: This study was undertaken to compare the postoperative peri-implant fracture rates between intertrochanteric femur fractures treated with either a long or short cephalomedullary nail.

Methods: This retrospective cohort study was conducted at a Level I trauma center in patients admitted between January 2005 and April 2014. All included patients were at least 65 years of age and sustained an intertrochanteric femur fracture that was treated with either a long or short cephalomedullary nail. Patients were excluded if they sustained a pathologic fracture, had previous surgery on the ipsilateral hip, or had follow-up <3 months.

Results: There were 1068 Intertrochanteric femur fractures in patients at least 65 years of age who were identified by the trauma registry. 175 patients were excluded, leaving 893 patients for review. Patients were treated with 600 (67.2%) short and 293 (32.8%) long cephalomedullary nails, at the treating surgeon's discretion. No significant differences were found in baseline demographics, medical comorbidities, or ISS between the 2 cohorts. There were also no significant differences between any of the primary or secondary end points including: hospital length of stay (7.1 vs 6.8, P = 0.407), mortality (1.3% vs 2.7%, P = 0.139), overall reoperation rate (5.2% vs 3.8%, P = 0.240), and reoperation rate secondary to peri-implant fracture (1.2% vs 0.7%, P = 0.726).

Conclusion: There is no difference in risk of postoperative peri-implant fracture in intertrochanteric femur fractures treated with either a long or short cephalomedullary nail. For intertrochanteric femur fractures without subtrochanteric extension, a short cephalomedullary nail can be used without increased risk of peri-implant fracture. Additionally, given preexisting data concerning cost savings and shorter operative time with less blood loss, short cephalomedullary nails should be utilized for unstable intertrochanteric femur fractures without subtrochanteric extension.

Efficacy of Carbon Fiber-Reinforced PEEK Femoral Nails: Preliminary Results

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Purpose: Carbon fiber has been used in several applications due to its mechanical properties but its use has been limited due to both cost and acceptance. Recently, carbon fiber (CF)-reinforced polyetheretherketone (PEEK) implants have become available at a price point commensurate with traditional metal implants. The CF implants have a modulus of elasticity between titanium and human bone and fatigue properties that are superior to metallic implants, thus they may provide better biologic and biomechanical characteristic for fracture treatment. The implant is approved by the US Food and Drug Administration and has been used for several years but with little literature surrounding its use. The current report focuses on the initial results of a CF femoral nail.

Methods: An IRB-approved, retrospective review of cases performed by the authors was undertaken. Inclusion criteria were diaphyseal femur fractures amenable to either antegrade or retrograde femoral nailing. Exclusion criteria were pathologic fractures, inadequate follow-up, and fractures with extension into the periarticular region. Routine demographic data were recorded as were any complications related to the surgery or implant. Outcome variables were percent healing at 2, 6, 12, and 18 weeks, infection, failure, or other complication. Since the goal was safety and efficacy, functional outcomes were not reported but patient questioning included any pain related to hardware.

Results: A total of 50 patients were reviewed, with an average age of 45 years. Of the 50 patients, 38 had follow-up until healing. Of the 38 patients, 66% demonstrated healing by 6 weeks, and 96% demonstrated healing by 12 weeks. The 1 fracture that did not heal "autodynamized (broken proximal interlocking screws)" and the patient was lost to follow-up. There were no infections or hardware failures, and patients did not complain of hardware-related pain or barometric pain.

Conclusion: The healing rate of a CF femoral nail is similar to reported rates of 96%, but unlike metallic nails, we noted a greater percent of cases healed at the 6-week time period. We also noted the lack of barometric or hardware-related complaints. We attribute these findings to the lower modulus of elasticity, which may promote faster healing. The lack of any hardware-related patient complaints may be due to the lower modulus. While the fatigue properties of CF are superior to metal, we could not make any conclusions about the longevity of the implant. In summary, the CF femoral nail appears safe and effective with the appearance of faster callus and healing. Further study is warranted.

See pages 401 - 442 for financial disclosure information.

Healing of Atypical Subtrochanteric Femur Fractures After Cephalomedullary Nailing: Which Factors Predict Union?

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Purpose: The purpose of this study was to (1) determine the healing rate and time to union of atypical subtrochanteric fractures treated with cephalomedullary nailing, (2) evaluate the factors that may affect healing of these fractures, and (3) report the complications encountered after cephalomedullary nailing.

Methods: Between January 1, 2005 and December 31, 2013, 132 suspicious, atypical femur fractures associated with bisphosphonates in patients presenting to 6 level I trauma centers in the Asia-Pacific region were screened for enrollment. The final cohort included 42 patients with 48 displaced, atypical, bisphosphonate-associated subtrochanteric femur fractures. Data were collected using a unified Case Report Form from each center. Surgical records included the operative report for the surgical procedure, reduction technique, presence of reaming and amount of over-reaming of the intramedullary canal, and the type of implant used. Radiographs taken preoperatively, in the immediate postoperative hospitalization period, and at 3-month intervals postoperatively were evaluated in the study. The primary outcome in this study was radiographic healing and healing time.

Results: The primary healing rate after cephalomedullary nailing of bisphosphonate-associated subtrochanteric femur fractures was 68.7% (33 of 48 patients). Mean time to union was 10.7 months. Malalignment was determined using the differences in neck-shaft angle (the difference between the normal side and the surgically repaired side), and sagittal angulation. These all proved to be significantly correlated with failure and delayed healing time. The cutoff points for neck-shaft angle, difference in neck-shaft angle, and sagittal angulation were 125.6°, 4.4°, and 5.5°, respectively (receiver operating characteristic [ROC] curve analysis).

Conclusion: The healing rate of atypical subtrochanteric femur fractures treated with cephalomedullary nailing is lower than that previously reported for atypical femur fractures. The quality of fracture reduction proved to be the most important factor in bony union and time to union.

Low-Energy Gunshot Injuries to the Femur:
What Is the Utility of Stabilizing Incomplete Fractures?

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Purpose: Extremity involvement is common among gunshot injuries, 57% with associated fractures. Patients may present with cortical penetration of the bullet without a complete fracture, thus without displacement. Treatment recommendations are variable with some advocating protected weight bearing to promote healing without fracture displacement, and with others performing prophylactic stabilization to protect against displacement of the fracture. The purpose of this study was to review our experience in the management of these injuries and to develop treatment recommendations.

Methods: 51 skeletally mature patients were treated over 15 years at an urban Level I trauma center for incomplete fractures of the femur secondary to low-energy gunshot. One died from severe head injury on the date of presentation. Clinical and radiographic data were obtained for the other 50 patients. Fracture patterns included AO/OTA 31 (n = 4), 32 (n = 31), and 33 (n = 15). All fractures were nondisplaced and extra-articular.

Results: 49 men and 1 woman with mean age 22.7 years (range, 16-58), and mean body mass index (BMI) 29.5 (range, 18.8-40) were included. 14 were obese with BMI>30. 34 had injury isolated to the femur, while 7 had injuries to other body systems, and 9 had other fractures. 36 patients (72%) were managed nonoperatively with protected weight bearing for 6 weeks, while 14 patients (28%) underwent prophylactic fixation of the femur. No differences in treatment were seen based on age, BMI, fracture pattern, or presence of other fractures or system injuries. Prophylactic surgery was more likely over time: 16.7% during the first 5 years of study, 21.4% over the middle 5 years, and 40% during the last 5 years. Two of the 36 patients (5.6%) treated nonoperatively for shaft fracture fell at 10 days and 5 weeks after injury and displaced their fractures. Both underwent reduction and fixation. All other fractures maintained alignment until union. No infections or nonunions were seen. Among patients who underwent prophylactic fixation, 2 underwent removal of prominent implants after union. Two patients returned for removal of prominent bullet fragments at 4 weeks and 3 years after injury.

Conclusion: Less than 6% of incomplete femur fractures treated at our hospital required later surgery for fracture displacement. Although incomplete fractures occur infrequently, nonoperative management appears successful and cost-effective for most patients. We propose this strategy, and potentially extrapolating it to similar fractures in other locations.

See pages 401 - 442 for financial disclosure information.

Treatment of Intertrochanteric Femur Fractures with Long Versus Short Intramedullary Nails: Analysis of a Hip Fracture Registry

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Purpose: The purpose of this study was to assess failure and complications associated with short versus long cephalomedullary nails for intertrochanteric femur fractures. Risk of revision was the outcome of primary interest. Secondary outcomes included risk of periprosthetic fracture, blood loss, operative time, and length of stay.

Methods: We conducted a retrospective cohort study using data collected prospectively through our integrated health-care system's hip fracture registry with intertrochanteric femur fractures identified using ICD-9-CM code. A total of 5526 patients were identified with an intertrochanteric femur fracture who underwent treatment with a cephalomedullary nail between 2009 and 2014. Long nails were used in the treatment of 3108 patients and for 2418, short nails were used.

Results: 96 revisions occurred (1.7%) with 50 revisions among long nails (1.6%) and 46 among short nails (1.9%). 24 revisions were for periprosthetic fracture (0.4%) with 11 among long nails and 13 among short nails. Cox regression with propensity score weights (used to balance the groups on patient and device characteristics) indicated no significant difference in risk for revision, hazard ratio (HR) = 0.75 (0.48, 1.15), P = 0.186, or periprosthetic fracture, HR = 0.59 (0.23, 1.48), P = 0.258. Linear regression with propensity score weights indicated longer nails resulted in significant increases in operative time (minutes), b = 18.8 (17.33, 20.27), P <0.001, blood loss (mL), b = 41.10 (31.71, 50.48), P <0.001, and length of stay (days), b = 0.35 (0.12, 0.58), P = 0.003.

Conclusion: No difference was detected in the risk of revision or periprosthetic fracture for long versus short nails in the treatment of intertrochanteric femur fractures. Longer nails resulted in operative times that were approximately 19 minutes longer, 41 mL more blood loss, and a length of stay that was a third of a day longer.

Is the Posterior and Cranial Screw of the Inverted Triangle Configuration for Femoral Neck Fracture Fixation Safe?

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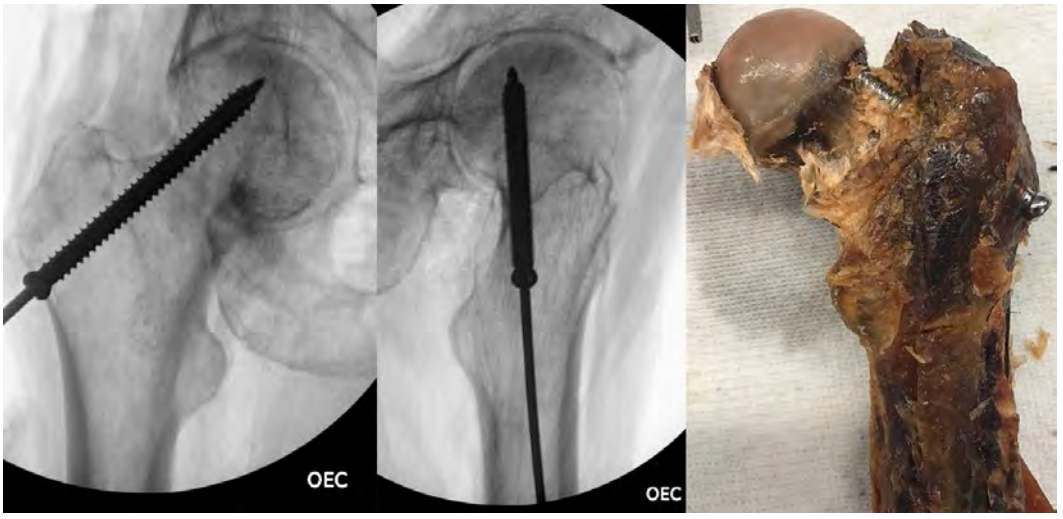
Purpose: In femoral neck fractures, a biomechanically advantageous construct is achieved with 3 screws placed in the inverted triangle fashion parallel to the peripheral cortex. Iatrogenic perforation of the posterior-cranial cortex may have devastating consequences with the potential for disruption of the vascular supply to the femoral head. The purpose of this study was to determine if the posterior-cranial screw that appeared contained on fluoroscopy did not violate the cortex.

Methods: Ten hemipelves with the proximal femur were obtained from embalmed cadavers. Under fluoroscopy, only the posterior-cranial screw of the inverted triangle configuration was placed using standard technique. AP and lateral images of the final screw placement were blinded to 2 orthopaedic traumatologists and 1 musculoskeletal radiologist who were asked to determine if the screw radiographically breached the posterior-cranial cortex. Cadavers were stripped of soft tissues and inspected for screw perforation. Screws were grouped as contained, thread extrusion, or core extrusion.

Results: Reviewers classified all 10 screws as radiographically contained within the femoral neck. Cadavers were inspected and found to show: 4 of 10 with core extrusion (Fig. 1), 3 of 10 with thread extrusion, and 3 of 10 screws contained within the femoral neck.

Conclusion: 70% of screws that were judged to be radiographically contained had cortical breach near the area where the lateral epiphyseal vessels enter the femoral neck. We urge caution against placement of posterior-cranial implants even if they appear radiographically contained.



See pages 401 - 442 for financial disclosure information.

Clinical Significance of Cortical Perforation During Fixation of Femoral Neck Fractures: Does the "In-Out-In" Screw Matter?

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Purpose: Cannulated screw fixation (CSF) is commonly utilized in treatment of femoral neck fractures (FNFs). Use of a modified inverted triangle configuration of 3 screws places the posterosuperior screw in close proximity to the lateral epiphyseal artery if cortical perforation were to occur. Intraoperative fluoroscopic evaluation of the posterosuperior femoral neck is difficult. We sought to compare the clinical fate of hips with a confirmed extraosseous screw to those without, and to determine surgeon accuracy in confirming an intraosseous screw pathway based on fluoroscopy.

Methods: All patients who underwent CSF of an FNF from 2005 through 2015 were identified. Postoperative CT scans of the pelvis were reviewed for violation of the cortex of the femoral neck. Radiographic or CT signs of ON (osteonecrosis), and conversion to hip arthroplasty (HA) were recorded. Additionally, a 3.2-mm guide pin was placed into the posterosuperior quadrant of 11 adult-sized foam cortical femora. Five samples were "all-in" and 6 were "in-out-in." Ten fluoroscopic images (5 AP and 5 lateral views) were obtained at 10° intervals of each model. The images were reviewed in a blinded fashion by 5 attending orthopaedic trauma surgeons and 20 resident surgeons. Accuracy and interobserver reliability were assessed.

Results: 362 patients underwent CSF of an FNF from 2005-2015, and in 104 patients a CT of the pelvis was available at a mean of 32 months postoperatively. Mean age was 73 years. In 55 (53%) of 104 patients the posterosuperior screw was extraosseous. The rate of ON was 5% and 2% ($P > 0.1$) and the rate of conversion HA was 4% and 2% ($P > 0.1$) in patients with and without an extraosseous screw, respectively. In the foam cortical models, accuracy in predicting cortical perforation showed substantial interobserver reliability with $\kappa = 0.70$. Accuracy was 87% among attending surgeons and 86% among residents ($P = 0.50$). Sensitivity and specificity for detecting cortical perforation was 98% and 71%, respectively.

Conclusion: In a cohort of geriatric patients undergoing CSF of an FNF revealed a high rate of cortical perforation of the posterosuperior cortex as assessed by CT. The clinical consequences of this finding remain unknown, as the rates of conversion HA and ON did not correlate with cortical perforation. The surgeon's ability to determine an extraosseous screw pathway in the posterior superior neck is imperfect, even when utilizing a number of oblique fluoroscopic images.

Are Factor Xa Inhibitors Effective Thromboprophylaxis After Hip Fracture Fixation?

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Purpose: Current anticoagulants effectively mitigate venous thromboembolism (VTE) risk, but there is no clear consensus on the preferred agent after surgical fixation of hip fractures. Factor Xa inhibitors have been found to be effective in total joint arthroplasty, but the data on their use in hip fracture patients are limited. The purpose of this study was to directly compare the efficacy of factor Xa inhibitors, enoxaparin, and warfarin as VTE prophylaxis agents after surgical fixation of hip fractures in large cohorts of patients.

Methods: We queried a combined private-payer and Medicare database from 2007-2015. We identified all patients who had surgical fixation of a hip fracture. Any patient with antiplatelet or anticoagulants prescribed within 1 year prior to hip fracture was excluded. We identified patients who had factor Xa inhibitors, enoxaparin, and warfarin first prescribed within 2 weeks of surgical fixation. Cohorts were matched by age and gender. Charlson Comorbidity Index (CCI) was calculated, and complication incidences were compared.

Results: We analyzed 2326 hip fracture patients who had enoxaparin, 929 patients who received a factor Xa inhibitor, and 835 patients who had warfarin. The average CCI for each group was 3, indicating similar overall health status. Factor Xa and enoxaparin had comparable incidences of deep venous thrombosis (DVT) at 90 days (4.31% and 4.94%, respectively), while warfarin therapy resulted in a statistically significant higher DVT incidence (6.71%). Pulmonary embolism incidence was lowest in enoxaparin at 1.25% and higher with both factor Xa inhibitors and warfarin (2.15% and 2.63%, respectively). Bleeding risk, anemia, and transfusion rates were comparable across all groups.

Conclusion: Enoxaparin and factor Xa inhibitors are both more efficacious than warfarin for VTE prophylaxis after surgical fixation of hip fractures. Given the cost of novel anticoagulants, enoxaparin may remain the preferred agent, although factor Xa inhibitors are a viable alternative.

See pages 401 - 442 for financial disclosure information.

Indications and Outcomes for Nail Plate Combination Technique in the Treatment of Complex Femur and Distal Femur Fractures, Nonunions, and Malunions: A Multicenter Collaborative Study

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Purpose: This study's investigators have been implementing nail plate combination (NPC) technique for AO/OTA type 32/33 fractures acutely, and in the nonunion/malunion setting. The purpose of this study is to compile data from 5 trauma centers to analyze the indications and outcomes following application of NPC technique.

Methods: Registry data from 5 trauma centers were screened for analysis. Inclusion criteria included complete medical and radiographic records. Data collected included age, gender, body mass index, comorbidities including diabetes, smoking history and dementia, ASA (American Society of Anesthesiologists) score, surgical indication, and implants used including plate length, location and number of linkages (if any) to the nail, and type of nail used. Healed status, final weight-bearing/ambulatory status, and any complications were also recorded.

Results: 89 patients (93 femurs) were screened for inclusion. Of the 93 cases, 43 (46.2%) were for nonunion, 39 (41.9%) were for acute fractures, 9 (9.7%) were for periprosthetic/peri-implant/interprosthetic fractures, and 2 (2.2%) were for malunion. 12 patients were lost to follow-up, and 3 patients died within the first 6 months following surgery. The final cohort consisted of 74 patients (78 femurs) included for analysis. 77 femurs (98.7%) went on to uneventful healing; 1 nonunion (1.3%) was in a diabetic smoker who required subsequent percutaneous bone grafting to reach union. All patients were weight -bearing as tolerated except 1 patient, who was nonambulatory at baseline. Additional complications included 1 superficial infection (1.3%) and 3 deep infections (3.8%) requiring return trips to the operating room.

Conclusion: NPC technique can be applied successfully not only in the setting of nonunion and malunion, but also in the acute fracture or periprosthetic or peri-implant fracture setting that may require additional stabilization due to a long segment fracture with poor bone quality. While clinical data are promising, further, specific indications along with biomechanical and finite element studies that may offer more insight as to why this fixation construct may be beneficial in these complex clinical scenarios.

Preliminary Report: A Prospective, Multicenter Cohort Study to Compare SIGN Nail and Skeletal Traction for Femoral Shaft Fractures in Malawi

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Purpose: The purpose of this study is to assess the quality of life of femoral shaft fracture patients treated by skeletal traction and Surgical Implant Generation Network (SIGN) IM nail in a resource-constrained environment.

Methods: Enrollment for this multicenter, prospective cohort study began in February 2016. Consecutive adult patients with femoral shaft fractures (AO/OTA 32) treated by skeletal traction or SIGN IM nail were enrolled at 6 hospitals in southern and central Malawi. Patients with polytrauma, surgical site infection, open fractures, and pathologic fractures were excluded. Primary outcome was the quality of life assessed by EQ-5D index (Zimbabwe) and EQ-5D visual analog scale (VAS). Secondary outcomes included patient-reported functional status using Short Musculoskeletal Function Assessment (SMFA), reoperation rate, complication rate, RUST score (Radiographic Union Score for Tibial Fractures), and objective clinical measures including Squat and Smile, Timed Up and Go, and Chair Stand Test. Patients were administered the EQ-5D and SMFA at baseline, then all subjective and objective tests at 6 weeks, 3 months, 6 months, and 1 year postoperatively.

Results: 260 patients with femoral shaft fractures were screened at 6 hospitals and 125 meeting eligibility criteria were consented (100% enrollment rate). There were 70 (56%) treated definitively by skeletal traction and 55 (44%) treated by IM nail. The most common mechanism of injury was road traffic injury (84%). At the time of this preliminary report, 62 patients reached 6-week follow-up, 43 reached 3-month follow-up, and 18 reached 6-month follow-up. No patients are yet eligible for 1-year follow-up. Patients treated with IM nail reported higher scores on the EQ-5D index, EQ-5D VAS, SMFA Functional Index, and SMFA Bothersome Index at 6 weeks, 3 months, and 6 months postoperatively ($P < 0.05$) compared to those treated with skeletal traction.

Conclusion: The high screening, enrollment, and preliminary follow-up rate demonstrate the feasibility of implementing a multicenter, prospective study in a resource-limited setting. The preliminary data suggest that up to 6 months postoperatively, patients with femoral shaft fractures report higher quality of life and functional outcome if treated with image-unassisted IM nail as compared to skeletal traction.

See pages 401 - 442 for financial disclosure information.

Are Retrograde Nails Better for Distal Femur Fractures in Obese Patients?

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Purpose: Fracture care in obese patients is challenging given the increased technical difficulty and the potential for higher complication rates. Distal femur fractures occur relatively infrequently; however, their prevalence is expected to increase with the aging population. There are currently limited data comparing retrograde intramedullary nailing to plate fixation in the obese population. We hypothesize that retrograde nailing is equivalent to plate fixation in the obese population and might offer some advantages.

Methods: We retrospectively reviewed our institution's fracture database to identify patients with distal femur fractures (AO/OTA Type 33) who underwent either plate or retrograde nail fixation. We included patients who were skeletally mature with a body mass index of 30 or greater per Centers for Disease Control and Prevention (CDC) guidelines for obesity. Other comorbid conditions and demographic data were also collected, as were details of surgery. The primary outcome measure was successful union; secondary outcome measures included operative time, estimated blood loss, infection, and time to weight bearing.

Results: We identified 85 patients with a total of 91 fractures; there were 61 fractures in the plate group and 30 fractures in the nail group. There were 14 nonunions (23%) in the plate group and 1 nonunion (3%) in the nail group ($P = 0.017$). However, the rate of open fracture was higher in the plate group (18 of 61 compared with 3 of 30) and was significantly predictive of nonunion ($P = 0.005$). On univariate analysis for closed fractures only, the nonunion rate was 14% for plates versus 3% for nails, but did not reach statistical significance ($P = 0.236$). Overall, there was a difference in time to union with a mean of 202 days for plates versus 107 days for nailing ($P = 0.03$). Once again, when nonunions were excluded from this analysis, there was no significant difference between the plate group (122 days) and nailing (105 days) ($P = 0.089$). Mean operative time for nailing was significantly less compared to plating (3.3 hours vs 4.4 hours; $P = 0.002$). Blood loss was significantly less in the nailing group (214 mL vs 296 mL; $P = 0.013$). The infection rate was equivalent with 3 infections in the plate group versus 2 in the nail group ($P = 0.999$). Time to weight bearing was similar between groups: 137 days for plating versus 105 days in the nail group ($P = 0.127$).

Conclusion: Retrograde nailing for distal femur fractures in obese patients provides equivalent outcomes compared with standard plate fixation and is associated with shorter operative times and less blood loss with a trend toward lower nonunion rates.

Quantitative Lesser Trochanter Versus Cortical Step Sign in Assessing Femoral Malrotation After Femoral Nailing

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Purpose: A technique that uses the relative sizes of the lesser trochanters to calculate the direction and magnitude of femoral malrotation after IM nailing has been recently described ("Quantitative Lesser Trochanter"), and we hypothesized that this technique would provide a better estimate of rotation than the previously described "Cortical Step Sign" technique.

Method: A transverse mid shaft osteotomy was performed on 11 cadaveric femora, a reamed IM nail placed, and a jig allowed for rotation of the proximal femur. Images were obtained of the proximal femurs and the osteotomy site at rotations of 0° and at random magnitudes of both internal and external rotation. A computer-based quiz was made from a random order of the 77 images of the proximal femur and 77 images of the osteotomy site. Six orthopaedic traumatology attendings or fellows who were blinded to the magnitude of malrotations estimated the amount and direction of malrotation using the "Cortical Step Sign" technique and to perform 3 measurements of the lesser trochanter size. Malrotation was then calculated based on a novel formula previously described (malrotation = 70 × (difference in lesser trochanter size/maximum lesser trochanter size)). Reliability was calculated using intraclass correlation coefficients (ICCs). The mean absolute difference between the true value and each measurement technique were compared using paired t tests.

Results: The ICC for the Quantitative Lesser Trochanter technique was 0.83 vs. 0.51 in the Cortical Step Sign technique (P <0.01). The Quantitative Lesser Trochanter estimates also demonstrated a stronger correlation (0.74) to the true values compared to the Cortical Step Sign technique (0.40). The mean difference between the absolute Quantitative Lesser Trochanter measurements and true value was 6.7° (95% confidence interval [CI]: 6.0-7.3) which was clinically similar to the 9.0° (95% CI: 8.3-9.7) using the Cortical Step Sign technique (P <0.0001).

Conclusion: The Quantitative Lesser Trochanter technique may provide an improvement in measurement accuracy (P <0.0001) and reliability (ICC: 0.83 vs 0.51) compared to the Cortical Step Sign technique. Furthermore, the Quantitative Lesser Trochanter technique provides an additional advantage over Cortical Step Sign in that the direction of the malrotation is calculated.

See pages 401 - 442 for financial disclosure information.

Results of Surgical Repair in Displaced Femoral Neck Fractures in Young Adults: Special Attention on the Effects of Construct Design

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Purpose: The purpose of this study was to assess the results of internal fixation for displaced femoral neck fracture in a population of young adults. Emphasis was placed on the effects of construct design on surgical outcomes.

Methods: This was a retrospective study of displaced femoral neck fractures in young adults (<60 years) at our Level I regional trauma center between January 1, 2005 and December 31, 2015. Collected data included demographics and comorbidities, injury, treatment, surgical outcomes, and complications. Healing was defined as restoration of 3 continuous cortical lines on plain radiographs of the hip (AP and lateral). Femoral neck shortening was measured using serial postoperative AP pelvis radiographs. The injured femoral neck was compared to the contralateral femoral neck using standardized 2-dimensional measurements.

Results: We identified 81 patients who met study criteria and had >6 months follow-up. Mean follow-up was 16 months (range, 6-52 months). Most of our patients were classified as Pauwels type III (74%) or II (26%). The predominant surgical constructs used were compression hip screw and antirotation screw (CHS + AR, 38%) and 3 or 4 cannulated screw fixation (CS, 51%). 11 hips (14%) subsequently developed osteonecrosis (CHS + AR, 16%; CS, 13%), 14 hips (17%) developed nonunion (CHS + AR, 16%; CS, 20%) and had additional surgery (NS). 54 patients had uneventful fracture healing (CHS + AR, 72%; CS, 63%). The femoral neck shortened >5 mm in 80% of patients (CHS, 58%; CS, 93%). The average amount of shortening in CHS + AR and CS fixation was 7.9 mm and 15.3 mm, respectively (P <0.01). Additionally, 14 hips (19%) treated with a fully threaded screw (FTS, length-stable implant) as part of a CHS + AR or CS construct experienced mean shortening of 6.2 mm, while 45 hips (61%) treated without an FTS experienced mean shortening of 14.7 mm (P <0.01). Patients treated with CHS + AR with FTS and CS with FTS experienced 5.1 mm and 5.9 mm of shortening, respectively. Patients treated with CHS and CS fixation without FTS experienced 8.5 mm and 18.2 mm of shortening, respectively.

Conclusion: In a sizable population of young patients treated for displaced femoral neck fractures using a number of modern construct designs, we found overall results as good as those previously published. CHS + AR and FTS as a length-stable implant are 2 effective means we have found that limit femoral neck shortening while allowing for healing in most cases.

Does the New CDC Definition of Postoperative Infection Make Sense for Orthopaedic Trauma?

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Purpose: In 2016, the Centers for Disease Control and Prevention (CDC) changed the time frame in their definition of deep surgical site infection from within 1 year of index surgery to within 90 days. However, it is not uncommon for orthopaedic trauma patients to present with infection following fracture fixation beyond this time period. We hypothesized that a substantial number of infections in patients that had fracture fixation present beyond 90 days and that there are patient factors that distinguish this late presenting group from the earlier presenting group.

Methods: A retrospective review yielded 452 deep surgical site infections following fracture fixation between 2006 and 2015. This cohort of 452 patients was divided into 2 groups consisting of those who became infected within 90 days (308 patients) and those who became infected after 90 days (144 patients). Data were collected on multiple factors identified as being theorized risk factors for infection. Bivariate and multiple logistic regression analyses using these variables were performed to directly compare the 2 groups. A randomly selected control group was used to build infection prediction models for both outcomes. The 2 outcomes were then modeled against each other to determine if differences in the predictors for early versus late infection exist.

Results: Of the 452 infections identified, 144 of these infections occurred beyond 90 days (31.8%). There were no statistically significant patient factors found in logistic regression models between the early and late infection groups. The need for flap coverage as a result of initial soft-tissue injury was the only injury characteristic that differed significantly between the groups, with patients in the late infection group more likely to have needed a flap. When early infection is modeled against late infection, the only predictor of infection greater than 90 days postoperatively is need for flap coverage. Predictors for early and late infection (against the control group) are identical.

Conclusion: At our Level I trauma center, 31.8% of fracture patients who became infected did not meet the new CDC definition of postoperative infection. This suggests that the new CDC definition underestimates the rate of actual postoperative infections when applied to orthopaedic trauma patients. There are no identified patient-specific variables that make patients more susceptible to early versus late infection, although patients who require a flap for soft-tissue coverage are more likely to present with a late infection.

See pages 401 - 442 for financial disclosure information.

The Hyperextension Tibial Plateau Fracture Pattern: A Predictor of Poor Outcome

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Purpose: Bicondylar tibial plateau (BTP) fractures are the most common fractures that affect the knee. Hyperextension BTP (HEBTP) fractures are an important, but understudied, subset of BTP fractures. The intention of this retrospective analysis was to compare the clinical and functional outcomes of patients with HEBTP fractures, both in varus and valgus, to those with other complex BTP fractures.

Methods: This study was a retrospective review of tibial plateau fractures over a 7.5-year period. A consecutive series of BTP fractures that met criteria were included. The following were required for inclusion in this analysis: Schatzker V or VI fracture pattern (OTA type 41-C), complete imaging, and a minimum 1-year follow-up. Patient demographics, radiographic, clinical and functional outcomes using the Short Musculoskeletal Function Assessment (SFMA), and all complications were recorded. Patients were divided into 2 groups, either hyperextension or non-hyperextension injury mechanism, based on standardized radiographic criteria and compared. The HEBTP fractures were those determined to have the following radiographic findings: (1) loss of the normal posterior slope of the tibial plateau, (2) tension failure of the posterior cortex, and (3) compression of the anterior cortex. Follow-up data was obtained at standard follow-up time points for both groups, and analyzed.

Results: A total of 84 patients were included in the study. There were 69 patients with 69 knees (82%) that had sustained non-hyperextension BTP fractures and 15 patients with 15 knees (18%) that had HEBTP fractures. Groups did not differ in regard to patient demographics, duration to follow-up, or range of knee motion at 1-year postoperative follow-up. Patients with hyperextension mechanisms did, however, have higher functional (SFMA) scores (33.6 ± 22.4 vs 19.6 ± 18, $P = 0.013$) and trended toward higher pain scores, indicating worsened functional outcomes. HEBTP fracture patients were also more likely than their non-hyperextension mechanism counterparts to have associated soft-tissue damage (27% vs 4%, $P = 0.011$) and to develop posttraumatic osteoarthritis (33% vs 10%, $P = 0.047$).

Conclusion: Non-HEBTP and HEBTP fracture patients have similar outcomes in terms of range of motion at approximately 1 year of follow-up, but differ significantly in terms of functional recovery and types of complications associated with their injuries. Physicians who care for these injuries now can counsel patients regarding potential outcomes and more realistic expectations regarding their prognoses.

The Association of Surgical Sequencing with Septic Complications in Bicondylar Tibial Plateau Fractures with Compartment Syndrome

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Purpose: Bicondylar tibial plateau fractures are the consequence of high-energy mechanisms. It has been shown that tibial plateau fractures that require fasciotomies have a high incidence of infection, which has not been conclusively explained. This retrospective review evaluated the effect of surgical sequencing on infection associated with open reduction and internal fixation (ORIF) of bicondylar tibial plateau fractures with associated compartment syndrome.

Methods: Between January 1996 and December 2015 inclusive, all patients sustaining a bicondylar tibial plateau fracture were identified from a single institution. The initial search identified 758 patients with 41C3 fractures, 129 of which required 4 compartment fasciotomies. Patients were excluded if the fasciotomy was performed at an outside institution prior to transfer, were treated with amputation during their initial hospitalization, were lost to follow-up, or the fracture was treated entirely with external fixation. 89 patients out of the 129 satisfied the inclusion criteria. External fixation was performed in all patients, and an urgent 4-compartment fasciotomy was performed either through single or dual incisions. Wounds were managed with wound VAC (vacuum-assisted closure), underwent repeat debridements every 2-4 days, and underwent either delayed primary closure, split-thickness skin grafting (STSG), or flap coverage dependent on the degree of soft-tissue injury. Septic complications were defined as a surgical site infection that required at least 1 return to the operating room.

Results: Analysis was conducted to determine the effect of timing of fixation relative to wound closure, type of wound closure, open fracture, single versus 2-incision fasciotomy, ISS, and vascular injuries. Out of the 89 patients who met inclusion criteria, 20 were diagnosed and treated for a deep infection. 15 patients had an open fracture, and there were 14 vascular injuries that required repair. Both open fractures ($P = 0.004$) and vascular injury ($P = 0.001$) were predictive of infection. We found no significant difference in infection rates between patients who had definitive ORIF before the soft-tissue envelope was completely closed ($P = 0.064$). Single incision fasciotomy decreases the need for STSG ($P = 0.001$).

Conclusion: Treatment of 41C3 fractures is challenging and in the presence of fasciotomies the timing of definitive fixation becomes more complex. In our study, while open injuries and vascular injuries were highly associated with deep infection, timing of ORIF in relation to definitive wound soft-tissue coverage was not. Single incision fasciotomy can decrease the need for STSG.

See pages 401 - 442 for financial disclosure information.

Mapping Recovery in Simple and Complex Tibial Plateau Fracture Fixation

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Purpose: The purpose of this study is to determine the trajectory of functional recovery following open reduction and internal fixation (ORIF) of tibial plateau fractures between set time points (0-6 months, 6-12 months, 1-5 years) and to compare this for simple (OTA 41-B) and complex (OTA 41-C) fractures. This information would be useful for prognostication when counseling patients.

Methods: Patients undergoing tibial plateau ORIF were enrolled into a prospective database at a Level I academic trauma center between 2005-2015. Functional outcome using the Short Form-36 Physical Composite Summary score (SF-36 PCS) was collected at baseline, 6 months, and 1 and 5 years postoperatively. The proportion achieving the Minimal Clinically Important Difference (MCID) between time points was calculated. Trajectory of recovery for patients with complex fractures (OTA 41-C) was compared to those with simple patterns (OTA 41-B). Means were compared using paired t tests, proportions using Fisher's exact test. Statistical significance was set at $P < 0.05$.

Results: 188 were enrolled: 129 (68.5%) simple and 59 (31.5%) complex patterns. Mean baseline scores were similar (simple 56.2 vs complex 56.3, $P = 0.9$). Mean SF-36 PCS improved significantly in both groups between 6-12 months ($P < 0.001$) and 1-5 years (simple $P = 0.01$, complex $P = 0.008$). In both groups, the baseline scores were not reached at 5 years. For each time point except 5 years, the SF-36 PCS was significantly higher in the simple group ($P < 0.001$, 5-year $P = 0.1$). The slope of improvement in the SF-36 PCS was steeper in the complex group for both the 6-12 month and 1-5 year periods. At 6 months, there was a significant difference between the groups in the proportion of patients achieving the MCID (simple 76% vs complex 95%, $P = 0.001$) with no difference between 6-12 months (simple 66% vs complex 66%). Between 1-5 years, proportionally more patients achieved the MCID in the complex group (74% vs 60%), although not statistically significant.

Conclusion: For ORIF of tibial plateau fractures, the trajectory of recovery is characterized by an initial decline in function from baseline, a steep improvement in the subsequent 6 months, and ongoing recovery up to 5 years. In the simple patterns, patients achieve higher function by 6 months when compared to the complex patterns. However, the complex patterns demonstrate a steeper trajectory of recovery between 6-12 months and 1-5 years with comparable scores between the groups achieved only at 5 years, suggesting that for complex patterns, recovery occurs more in the later time periods. In both groups, function does not improve to baseline by 5 years.

Arthrofibrosis Following Operatively Treated Tibial Plateau Fractures: Predictors and Outcomes

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Purpose: This study was performed to assess what patient and injury factors may predict knee stiffness following tibial plateau fractures.

Methods: Over 11 years, all operative tibial plateau fractures, treated by one of three surgeons at a single institution, were prospectively followed. Arthrofibrosis was defined as arc of motion 90° or less. Outcomes were evaluated using the Short Musculoskeletal Function Assessment (SMFA) and visual analog scale for pain scores at short-term and latest follow-up. Student t tests were used for continuous variables. Chi-squared analysis was used for categorical variables. Multiple linear regression analysis was performed for knee range of motion (ROM) and binary logistic regression analysis was performed for lysis of adhesions.

Results: 275 patients, with 279 tibial plateau fractures, were included in our analysis. At 3-month follow-up, 27.4% of operatively managed patients had a knee ROM of 90° or less. By long-term follow-up (mean = 18 months), 7.2% of operatively managed patients had had a knee ROM of 90° or less. At 3-month follow-up, multiple linear regression demonstrated open fractures (P = 0.037) and application of a knee spanning external fixator (P = 0.041) to be independent predictors of arthrofibrosis. At long-term follow-up, independent predictors of arthrofibrosis were the application of a knee spanning external fixator (P = 0.002), non-Caucasian ethnicity (P = 0.009), and developing a postoperative deep infection (P = 0.005). Functional outcomes were worse in patients who had knee stiffness compared to those who did not, at each time point. Lysis of adhesions with a manipulation under anesthesia for arthrofibrosis was performed in 3.3% of patients. There was a significant improvement in knee ROM by a mean of 55.14° (P <0.001) and functional outcomes (P = 0.006) when this procedure was performed for arthrofibrosis.

Conclusion: Predictors for the development of arthrofibrosis, following operative management of tibial plateau fractures, include application of a knee spanning external fixator, open fractures, non-Caucasian race, and the development of a postoperative deep infection. Lysis of adhesions was a reliable treatment for arthrofibrosis. Additionally, patients with arthrofibrosis have worse functional outcomes following tibial plateau fracture surgery. With the knowledge of predictors for the development of arthrofibrosis, orthopaedic traumatologists may be able counsel patients and provide early interventions aimed at improving these patients' long-term outcomes.

See pages 401 - 442 for financial disclosure information.

Risk Factors for Surgery to Treat Knee Stiffness Following Tibial Plateau Fracture Fixation

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Purpose: Knee stiffness is common after tibial plateau fracture surgery that occasionally requires further surgical treatment. The primary aim was to determine risk factors for knee stiffness surgery following tibial plateau fixation. The secondary aim was to determine factors that predict failure of the subsequent knee stiffness surgery.

Method: The study groups were created for a case control study from a prospectively collected database of all 951 tibial plateau fractures treated with ORIF between 2007 and 2016 at a single Level I trauma center. The study group was 110 patients (12%) who had knee stiffness surgery that we defined as receiving a manipulation under anesthesia, arthroscopic lysis of adhesion, or quadricepsplasty after the fixation surgery. The control group was 319 tibial plateau fracture patients treated with ORIF without knee stiffness surgery with either a minimum of 1 year follow-up or clearly documented range of motion >110° with at least 90 days follow-up. Stepwise modeling techniques were used to select covariates based on a minimum AICc (Akaike Information Criterion) to be included in the final logistic regression models.

Results: The number of weeks in an external fixator (odds ratio [OR]: 1.6 per week, 95% confidence interval [CI]: 1.3-1.8, P<0.001) was the strongest predictor of need for a subsequent knee stiffness surgery, followed by having bilateral tibial plateau fractures (OR: 4.9, 95% CI: 1.6-15.0, P <0.01). No other factors were significant (P >0.20). The mean range of motion at follow-up after knee stiffness surgery was 105° (SD: 23.3), compared to 122° (SD: 14.4) in the control group (P <0.001). For patients with knee stiffness surgery, covariates including deep surgical site infection (-8.7°, P <0.01), having an upper extremity fracture (-4.8°, P = 0.02), and older age (-0.50°4˚ per year, P <0.01) were all associated with limited range of motion at follow-up. Improved range of motion after knee stiffness surgery was associated with patients of high socioeconomic status (15.7°, P = 0.02) and the number of weeks in external fixation (2.2° per week, P <0.01).

Conclusion: Clinicians should be aware that time spent in external fixation (P <0.001) and the presence of bilateral tibial plateau injury (P <0.01) are strong risk factors for requiring subsequent knee stiffness surgery. The patients with longer external fixator time may represent selection bias of worse soft-tissue injuries, but our finding may influence surgeons to remove external fixators earlier when possible.

Total Knee Arthroplasty After Tibial Plateau Fracture Is Not Common and Occurs Early After the Injury

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Purpose: Total knee arthroplasty (TKA) is a common salvage operation after failed treatment of a tibial plateau fracture due to the development of posttraumatic osteoarthritis. The rates and timing of conversion to TKA after tibial plateau fracture has a limited number of reports in the literature. The purpose of this study was to utilize a large national database with longitudinal tracking capability to investigate the rate and timing at which patients with tibial plateau fractures are secondarily converted to TKA.

Methods: The PearlDiver Research Program was used to query the Humana administrative claims database from 2007 to the third quarter of 2015. Patients with tibial plateau fractures were identified using CPT codes and laterality modifiers. Patients were then followed over time to determine the frequency and timing of conversion to ipsilateral TKA.

Results: 4427 tibial plateau fractures were identified that underwent either closed or operative treatment of a tibial plateau fracture during the study period (2287 closed treatment, 2140 operative). There were 1579 males (35.7%) and 2848 females (64.3%), with 886 patients age <50 years (20.0%) and 3541 patients age >50 (80.0%). Overall, 81 of 4427 (1.8%) of these patients had subsequent ipsilateral TKA after a tibial plateau fracture. The rate of conversion to TKA after an operatively treated plateau fracture was 2.1% (44 of 2140), while the rate of progression to TKA after a nonoperatively treated fracture was 1.6% (37 of 2287). These rates are not significantly different (P = 0.28). Approximately half (41 of 81, 50.6%) of all patients progressing to TKA had done so by 12 months, 61 of 81 (75.3%) by 24 months, and >90% had progressed to TKA by 48 months. When comparing operatively versus nonoperatively treated fractures that went on to TKA by 24 months, there were 88.6% (39 of 44) in the operative group and only 59.5% (22 of 37) in the nonoperative group (P = 0.002). No patients less than 50 years of age at the time of fracture went on to TKA, and there were no differences in rates of subsequent conversion TKA between genders.

Conclusion: Failure of treatment resulting in conversion to TKA after tibial plateau fracture is uncommon. Most patients after either operative or nonoperative treatment of a tibial plateau fracture maintain their native joint at midrange follow-up. If progression to TKA occurs, it is typically within the first 2 years after initial management.

See pages 401 - 442 for financial disclosure information.

Systemic Inflammatory Response Syndrome in Multiply Injured Children and Adolescents: Are Kids More Resilient?

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Purpose: Systemic inflammatory response syndrome (SIRS) is a well-recognized phenomenon in adult trauma populations. The "initial hit" of the traumatic event is often coupled with a systemic immune response characterized by changes in vital signs and laboratory indicators. A "second hit" from surgery during this time frame often results in acute lung injury (ALI), along with deterioration of the patient's clinical condition. "Damage control orthopaedics" (DCO) was born out of a desire to temporarily stabilize fractures in order to decrease the rate of ALI. While children are also involved in polytrauma, ALI has not been observed at the same rate and extent as it is in adults. This study sought to characterize the SIRS response in children and adolescents, and identify the differences between this population's response and the historical response of adults.

Methods: We queried the trauma database of our Level I pediatric trauma center from January 2005 to December 2015 for patients with ISS >16 and age >2. The electronic medical record (EMR) for these patients was followed for the first 4 days of their injuries and their SIRS criteria were tracked. Additionally, the patients were subcategorized into major orthopaedic injuries (femur fractures, pelvis or spine fractures), and patients without such injuries as well as by age. A total of 294 patients met inclusion criteria. The average ISS was 26.1 ± 9.2.

Results: 81.4% (in the orthopaedic injury group) and 69.1% (in the non-orthopaedic injury group) reached the threshold for SIRS within their first 4 days of hospitalization. Nine patients died in the hospital. Only 2 of the patients with major orthopaedic trauma developed the criteria for ARDS (acute respiratory distress syndrome). Increasing age groups showed increasing proportion of SIRS patients; in age group 2-5 years, 61.7% met SIRS criteria during their hospitalization, whereas in 6-12 there were 72.9%, and in the 13-18 years group there were 82.4%. Increasing ISS and increasing age were independent predictors of SIRS during the hospital stay.

Conclusion: SIRS appears to be as common in children as the reported rates in adults. The proportion of SIRS in children increases with increasing age and injury severity. The high mortality rate and rate of ARDS observed in adults was not present in our cohort.

Does Delay to Surgery in Type III Supracondylar Humerus Fractures Lead to Longer Surgical Times and More Difficult Reductions?

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Purpose: As numerous studies have shown that delay in reduction of pediatric supracondylar humerus fractures (SCHFx) does not affect clinical outcomes, and as many hospitals adopt dedicated daytime trauma operative time, more type III SCHFx are being pinned non-emergently after hospital admission. We sought to determine if delay in surgical treatment of type III SCHFx would affect the length of operative time.

Methods: This is an IRB-approved, retrospective review of a series of 309 modified Gartland type III supracondylar fractures treated operatively at a tertiary referral center from 2011 to 2013. Mean patient age was 5.4 years (range, 2-10). To balance the study design, 15 hours was selected as the cutoff between early and delayed treatment. 53.7% of fractures (166 of 309) were treated early, and 46.3% (143 of 309) were delayed. Surgical time was defined as "incision start" to "incision close." Fluoroscopy time was use as a surrogate for difficulty of reduction.

Results: Time from injury to operating room was shorter for high-energy fractures (fractures with soft-tissue or neurovascular injury) versus low-energy fractures (12.9 vs 15.3 hours, $P < 0.0001$); however, surgical time (37.3 vs 31.8 minutes, $P = 0.004$) and fluoroscopy time (54.6 vs 48.6 seconds, $P = 0.027$) were longer in high-energy fractures versus low-energy fractures. Among low-energy fractures, no significant difference was detected in surgical time between the early and delayed treatment groups (32.2 vs 31.4 minutes, $P = 0.514$) or in the fluoroscopy time (51.1 vs 46.3 seconds, $P = 0.646$). Additionally, there was no statistically significant difference found in surgical or fluoroscopy time with the presence of a surgical assistant. Mean surgical time when the attending surgeon was alone was 28.9 minutes, compared to 38.4 minutes with a fellow, 33.5 minutes with a resident, 34.8 minutes with a mid-level practitioner, and 40.9 minutes with both a fellow and resident ($P = 0.061$). Mean fluoroscopy time when the surgeon was alone was 42.3 seconds, compared to 58.2 seconds with a fellow, 51.3 seconds with a resident, 47.6 seconds with a mid-level practitioner, and 53.4 seconds with multiple trainees ($P = 0.127$).

Conclusion: Delay in surgery did not result in a longer surgical time or more difficult reduction for type III SCHFx. Patients with low-energy fractures still underwent a shorter operative time even with delay from injury to surgery. When excluding high-energy injuries, surgical treatment of Gartland type III SCHFxs may be delayed without increasing surgical time or difficulty of reduction.

See pages 401 - 442 for financial disclosure information.

Does a Delay in Treatment of Displaced Pediatric Lateral Condyle Fractures Increase the Risk of Complications?

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Purpose: This review was conducted to investigate factors associated with complications and the impact of timing of operative treatment on displaced lateral condyle fractures.

Methods: A consecutive series of lateral condyle fractures treated at a Level I pediatric trauma center between 2008-2014 were retrospectively reviewed. Fractures treated surgically that had at least 6 weeks of follow-up were included in this study. The maximal radiographic displacement (in AP, lateral, or oblique view) as well as the time from initial injury to surgical intervention were recorded. Univariate and multivariate statistical analysis was performed analyzing the correlation of maximal displacement and timing to surgery with the rate of specific complications of loss in early motion or delayed union. Logistical regression modeling was performed for 3 groups: those with mild displacement (>4 mm), moderate displacement (4-7 mm), and significant displacement (>8 mm). From this, an odds ratio (OR) was calculated.

Results: 408 patients (mean age 4.88 years, 68% males) met the inclusion criteria. 82 patients had complications: 66 with early stiffness, 2 with arthrofibrosis, 9 nonunion/delayed unions, 1 with osteonecrosis, and 4 with infection. Factors associated with the studied complications were older age (5.95 vs 4.63, P <0.01), increased fracture displacement (10.3 mm vs 7.8 mm, P <0.01), and total time immobilized (38.27 days versus 31.52 days, P = 0.001). When surgical treatment was greater than 1 day post-injury, the incidence of these complications was higher in those with >8 mm of displacement. In logistic regression modeling controlling for age and maximum displacement as independent variables, an increase in complication rate was seen (OR 1.317 and 1.117, P value 0.000, 0.001) when fractures underwent subacute fixation.

Conclusion: Both amount of initial displacement and time to surgical fixation of pediatric lateral condyle fractures affect the risk of specific complications including early stiffness and delayed union.The results of our study suggest that early intervention may be warranted for displaced lateral condyle fractures.

Complications After Titanium Elastic Nailing of the Forearm

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Purpose: Titanium elastic nailing is the most common method of operative treatment of pediatric forearm fractures. It is believed to be safe and reliable with high rates of good to excellent results. However, published complication rates vary widely and are as high as 50%. The purpose of this study was to evaluate complications after titanium elastic nailing of forearm fractures at our institution.

Methods: We retrospectively reviewed 243 consecutive pediatric patients from 2007-2014 who underwent titanium elastic nailing of a forearm fracture. Medical records were reviewed to determine age, gender, reason for surgery, closed versus open fracture, need for open reduction, bones instrumented, removal of implant, date of removal, complications, and length of follow-up. Complications consisted of any deviation from the postoperative course that could possibly be attributed to the nail itself or the procedure. These were divided into minor complications (transient tendon or nerve injury and implant prominence/pain requiring early implant removal prior to 3 months postoperatively) and major complications (delayed/nonunion, refracture, and extensor pollicis longus [EPL] rupture). Univariate logistic regression was used to compare variables between those with minor and major complications and those without.

Results: 243 patients were identified with a total of 345 nails (158 ulnar, 187 radial) for 7 distinct fractures types: 151 both bone forearm fractures, 7 ulnar shaft fractures, 25 radial shaft fractures, 24 radial neck fractures, 24 Monteggia fractures, 10 radial neck with olecranon fractures, and 3 Galeazzi fractures. 65 of the 243 patients (26.7%) sustained a total of 71 complications. Minor complications consisted of 30 patients (12.3%) with painful/prominent implants requiring early implant removal, 16 patients (6.6%) with transient superficial radial nerve paresthesia, 7 (2.9%) with EPL irritation, and3 (1.2%) with transient ulnar neuropraxia. 15 of the 243 patients (6.2%) sustained a major complication consisting of 9 (3.7%) refractures, 3 (1.2%) delayed/nonunions, 2 (0.8%) malunions, and 1 (0.4%) EPL rupture. Two refractures and 1 delayed union occurred after removal of implants prior to 3 months postoperatively. With regard to total complications, instrumentation of both bones ($P = 0.004$) had a significantly increased rate of complications. Open reduction carried an increased risk of major complication ($P = 0.044$), while dorsal insertion of radial nail trended toward a significantly increased rate of major complication ($P = 0.056$). 13 of 75 patients (17.3%) who underwent open reduction sustained a major complication in our study group.

Conclusion: Titanium elastic nailing continues to be the most common method of treating pediatric forearm fractures. However, it is not without risk. Our study suggests that this method of fixation carries a high rate of complications, although most are transient and resolved with implant removal. Fractures requiring open reduction carried an increased rate of major complication, although our total rate compares similarly to previous published complication rates of pediatric forearm fractures treated with plate fixation.

See pages 401 - 442 for financial disclosure information.

Percutaneous Versus Open Reduction and Fixation for Tillaux and Triplane Fractures: A Multicenter Study

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Purpose: For Tillaux and triplane ankle fractures, treatment via both open and percutaneous techniques has been described. The literature contains supportive evidence for both techniques, leaving no general consensus on which is superior when it comes to minimizing residual gap or preventing growth disturbance. In this study, we present a multicenter initiative comparing the 2 techniques in a large, cohort comparison.

Methods: Four academic pediatric orthopaedic centers participated in this retrospective cohort comparison study. Two cohorts were formulated dependent on operative technique: percutaneous (PERC) or open reduction (OPEN). Inclusion criteria included all healthy, adolescent children undergoing operative fixation for either Tillaux or triplane ankle fractures with minimum 1-year follow-up. Data collected included age, gender, body mass index (BMI), diagnosis, time to surgery, operative technique, initial displacement, residual gap, and/or any radiographic signs of growth disturbance.

Results: A total of 68 patients met inclusion criteria and were included for analysis. The OPEN group consisted of 52 patients, while the PERC group consisted of 16 patients. There were no significant differences in age, gender, BMI, or diagnosis between the 2 cohorts. While results exhibited a significantly higher initial displacement in the OPEN group (4.4 $\pm$ 2.2 mm vs. 2.7 $\pm$ 1.9 mm, P = 0.01), there was no significant difference in residual gap at final follow-up. Furthermore, at final radiographic follow-up, there were no significant differences in the presence of growth arrest.

Conclusion: Despite a significantly higher initial displacement in the OPEN group, a seemingly higher-energy injury did not yield any significant differences in residual gap or growth disturbances at final follow-up. In this multicenter study, both techniques yielded desired results; however, prospective, controlled comparisons are required to truly delineate a difference.

The Treatment of Complex Pediatric and Adolescent Tibial Fractures with the Ilizarov Method

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Purpose: We analyzed the functional and psychological outcomes in children and adolescents with complex tibial fractures treated with the Ilizarov method at our major trauma center.

Methods: Patients aged ≤17 years treated with a circular frame for an acute tibial fracture between 2013 and 2016 were identified from our prospective database. Information from this database was supplemented by retrospective review of clinical notes and radiographs as well as routinely collected functional and psychological assessments. The patient-reported outcome measures administered 6 months post frame removal were the Pediatric Quality of Life Inventory (PedsQL) and a global health visual analog scale (VAS) to assess how they rated their overall health on a scale of 0-100 (0 = worst possible health, 100 = best possible health).

Results: 74 patients (59 male, 15 female) aged between 4 and 17 years with 75 tibial fractures were identified. The average weight was 51 kg (range, 16-105 kg). 26 patients had open fractures (6 with segmental bone loss) and 18 had associated physeal injuries. The remainder were closed fractures with unstable fracture patterns or significant soft-tissue compromise. 11 patients were included after failing alternative treatment. There was a 100% union rate with a median hospital stay of 4 days (interquartile range [IQR], 2-7) after frame application and a median frame time of 108 days (IQR, 93-137). Malunions (>5° in any plane) were not observed and no serious complications occurred. Health-related quality of life measures (Peds QL), where available (78%), indicate return to high levels of function 6 months post frame removal (median PedsQL 88.04; IQR, 70.32-100). The median global health VAS score was 95 (IQR, 80-99).

Conclusion: This largest series to date demonstrates the safety and effectiveness of the Ilizarov method in treating complex pediatric tibial shaft fractures, with 100% union and a low serious complication rate. Furthermore, patient-reported outcomes indicate high physical and psychosocial functioning following treatment.

See pages 401 - 442 for financial disclosure information.

Severely Injured Pediatric Patients with Major Orthopaedic Injuries Have Higher Mortality Rates and Greater Resource Utilization

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Purpose: Injury continues to be the leading cause of death for children worldwide and incurs significant psychosocial and financial burden. Direct and indirect economic costs are greatly affected by length of stay, medical treatments, and a reduction in quality-adjusted life years. The purpose of this study was to compare in-hospital complication rates, resource utilization, and mortality rates between pediatric trauma patients with and without major orthopaedic injuries.

Methods: Consecutive pediatric trauma patients (≤17 years of age) who met the highest-level trauma activation (January 2010 to May 2016) were included. Patients were dichotomized into ORTHO (extremity AIS ≥2) or non-ORTHO (extremity AIS <2). Demographics, vital signs, blood transfusions, and rapid thrombelastography (rTEG) were obtained upon hospital arrival. Continuous data were compared using the Wilcoxon rank sum test and categorical data were compared using Chi-squared or Fisher exact tests. Multivariate logistic regression analysis was completed using age, sex, ORTHO, Injury Severity Score (ISS), and admission haemoglobin to identify risk factors for predicting in-hospital mortality.

Results: 956 pediatric patients met inclusion; 337 ORTHO and 619 non-ORTHO. ORTHO patients were older (median 15 vs. 14 years), more commonly injured due to blunt trauma (86% vs. 65%), and presented with higher ISS (median 22 vs. 10); all $p<0.05$. The ORTHO group had an increased mortality (10% vs. 6%; $p = 0.05$), in-hospital pneumonia (6% vs. 3%), respiratory failure (19% vs. 12%), transfusion rate, and had fewer ICU-free and ventilator-free days; all $p<0.05$. Based on admission rTEG, ORTHO patients had significantly lower median 30-minute clot lysis level, a measure of degree of clot stability, (1.6 vs. 2.1; $p = 0.016$). and impaired fibrinolysis (38% vs. 28%; $p = 0.006$). On multivariate analysis, increased admission ISS (Odds Ratio = 0.90; 95% CI = 0.89 to 0.93; $p < 0.001$) and major orthopaedic injury (Odds Ratio = 1.99; 95% CI = 1.03 to 3.89; $p = 0.042$) were independent predictors of in-hospital mortality.

Conclusion: In 956 severely injured children, 35% presented with major orthopaedic injuries. Major orthopaedic injury was associated with increased in-hospital respiratory complications, higher mortality rates, and increased resource utilization. This study can be used to inform cost-analysis and demonstrates the need to evaluate current pediatric scoring systems for predicting mortality.

Safe Zone Quantification of the Third Sacral Segment in Normal and Dysmorphic Sacra

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Purpose: The purpose of this study was to radiographically quantify the osseous limits of the third sacral segment in patients with sacral dysmorphism and assess the potential for placement of an iliosacral screw in this segment.

Methods: A retrospective evaluation of a trauma database was performed. Inclusion criteria consisted of patients above the age of 18 years and had both pelvic radiographs and CT scans. A single investigator evaluated each patient's imaging, classifying them as having a normal or dysmorphic sacrum based on the criteria described by Routt. A second orthopaedic trauma fellowship-trained investigator, blinded to the classification of the sacra, analyzed each CT scan included in the study. The first measurement taken was the cross-sectional area of each safe zone. On both the true coronal and axial views, the angle of a screw that was parallel to the safe zone axis was measured relative to the horizontal. A safe zone diameter of 10 mm and 9 mm were used as the critical threshold as this would be a limit considered difficult by most surgeons using a 6.5-mm to 8.0-mm cannulated iliosacral screw.

Results: 30 patients (51%) were classified into the dysmorphic group. In the normal group, the average S3 coronal transverse width, replicating the outlet view, was measured to be 7.71 mm compared to 9.49 in the dysmorphic group ($P < 0.05$). The mean S3 axial transverse width in the normal group was 7.11 mm, as compared to 9.14 mm in the dysmorphic group ($P < 0.05$). 23 patients in the dysmorphic group could have a screw passing through the ilium, while only 12 patients could have the same in the normal group ($P < 0.05$). The mean S3 cross-sectional area of the normal group was 55.8 mm, as compared to 77.9 mm in the dysmorphic group ($P < 0.05$). Based on the aforementioned measurements, it was found that when using a safe zone threshold of 10 mm and available ilium, an S3 iliosacral screw could be placed in 7% of normal sacra and 14% of dysmorphic sacra. Using a safe zone threshold of 9 mm, an S3 iliosacral screw could be placed in 10% of normal sacra and 43% of dysmorphic sacra.

Conclusion: Our study demonstrated that the third sacral segment of dysmorphic sacra have a larger osseous pathway available to safely accommodate a sacroiliac screw when compared to those of normal sacra. Although there is sufficient area for an S3 screw to be placed in about half of dysmorphic sacra, surgeons should use their discretion and closely examine radiographs and CT scans prior to insertion of an S3 screw, since the diameter of the corridor is significantly smaller than those of S1 and S2 segments.

See pages 401 - 442 for financial disclosure information.

An Algorithm Can Predict Blood Product Transfusion Requirements in First 24 hours and 30-day Survival After Pelvic Fracture: 5-year Series of 589 Patients

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Purpose: Patients with pelvic fractures are at high risk of mortality and long-term morbidity. The fracture is just part of the injury profile. Our purpose is to identify specific factors, investigate their relative contributions and propose a "red alert" algorithm to predict mortality and blood transfusion requirements.

Methods: All pelvis fractures in our center from 2012 to 2017 were investigated. Data included ISS, GCS, injury mechanism, other injuries, 30-day survival and blood product use. Fractures were classified by two fellowship-trained surgeons. Regression models investigated predictors of 30-day survival and blood product usage.

Results: 589 patients had pelvic fractures, male 57% female 43%; median age 48(5-100). Injury mechanism was RTA 52%, fall>2m 28%, fall<2m 16%, other 4%. Fracture type was A(15%), B1(6%), B2(65%), B3(7%) and C(7%). Mean ISS was 23(+/-15, range 4-75) and varied with fracture type: ISS was significantly higher in C than non-C fractures (p=0.000). Mean GCS did not differ between C and non-C fractures (p=0.197). Overall 30-day survival was 95% and was worse in C (86%) than non-C fractures(93-97%), p=0.001. Multivariate logistic regression showed that 30-day survival is associated with increasing age, higher GCS, having a non-C fracture and absence of haemothorax (p=0.000). Abdominal or vessel injury, open pelvis fracture, longbone fracture, gender and injury mechanism were not significant. Linear regression showed that blood product requirement is associated with lower GCS and presence of: C-type fracture, abdominal organ injury, haemothorax, vessel injury, longbone fracture and open pelvic fracture (p <0.001). Age, gender and mechanism of injury were not significant. 30-day survival was 86% in C type and 95% in non-C fractures. This compared favorably to published results in other centers and highlighted the importance of vertically displaced injuries. The proposed algorithm for predicting 30-day survival and blood product usage in this dataset of 589 patients uses regression constants from the logistic and linear regression models.

Conclusion: The algorithm may be a valuable tool for clinicians managing pelvis trauma patients by identify high-risk patients. It may help define standards for trauma center practice. The influence of non-orthopaedic injuries on mortality and transfusion requirements highlights the benefits of multidisciplinary care.

Posterior Wall Acetabular Fracture Fixation Without Lag Screws

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Purpose: Posterior wall fractures occur with a shearing mechanism and fixation with independent lag screws and a buttress plate is considered the standard of care. However, the fracture is usually oriented close to the sagittal plane, mandating that lag screw fixation perpendicular to the fracture is at a severely acute angle to the retroacetabular surface. We sought to examine the effectiveness of peripherally placed underbent buttress plating without lag screws for the treatment of posterior wall acetabular fractures.

Methods: We reviewed a consecutive series of patients with isolated posterior wall acetabulum fractures all treated with a peripherally placed, underbent buttress plate to provide a compression of the fragment to the bed and resist posterior displacement of the head. Preoperative radiographs and CT scans were reviewed and the percent of the posterior wall intact, estimated fracture fragment width, posterior wall comminution, and whether the fracture apex extended to the acetabular roof were recorded. Postoperative radiographic evaluation included the quality of reduction, presence of any fixation in addition to the buttress plate, and the distance of buttress plate from acetabular rim. Complications were also documented.

Results: We reviewed 63 consecutive patients, (54 M; 9 F) aged 17-83 years (average 39) with an average body mass index of 30 who sustained OTA type 62-A1 posterior wall acetabulum fractures. Clinical and radiographic follow-up averaged 709 and 620 days, respectively. 75% of the patients were treated with buttress plating only. Additional miniplates more medially to support fragmented cortical retroacetabular cortical fragments were used liberally and antiglide plate was used superiorly to support extended superoanterior fractures when present. There were no losses of reduction in the series. One patient had pseudosubluxation on postoperative day 1, and was treated with femoral traction for 4 weeks. Six cases of heterotopic ossification and 3 cases of low-grade osteonecrosis were seen in follow-up. At final radiographic follow-up, the affected side joint space averaged 0.57 mm less than the contralateral side. There were no infections in the series.

Conclusion: This series demonstrates that posterior wall fractures can be effectively managed without lag screw fixation using an underbent peripherally placed buttress plate. The advantage of this method is the avoidance of lag screws close to the articular surface that may later create a more challenging conversion to total hip arthroplasty if needed and the more biomechanically sound peripheral position of the plate to resist posterior head translation.

See pages 401 - 442 for financial disclosure information.

The Utility of Obtaining Post-Mobilization Imaging in Nonoperative Pelvic Injuries

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Purpose: Pelvic fractures represent a wide spectrum of injury from high-energy, unstable patterns to low-energy, stable patterns that require minimal intervention. It can be difficult to determine where along this spectrum an injury pattern lies, and a missed unstable injury can be catastrophic. There exist protocols to determine stability intraoperatively, but this is resource-intensive and requires a general anesthetic. Another method is to obtain post-mobilization films (AP, inlet, and outlet views) to assess for early displacement. The purpose of this study was to investigate how often these radiographs diagnose occult instability and how many patients convert from nonsurgical to operative treatment.

Methods: Records at our single institution from 2007-2014 were retrospectively reviewed as identified by CPT and ICD-9 codes for pelvic fractures. Demographic data for 1057 patients were collected including age, gender, injury mechanism, and trauma activation status. 655 patients were treated operatively and 402 were planned for nonoperative treatment. For the 402 patients with an initial nonoperative treatment plan, a chart review was performed to identify those patients that had post-mobilization imaging obtained. Chart review after the post-mobilization imaging was completed to determine if treatment had changed based on the imaging.

Results: Of the 1057 patients identified, the average age was 50 years (±20 years), ranging from 18 to 103. 61% were male. The most prevalent mechanisms of injury were motor vehicle crash (40%) and fall from height (21%). 50% of patients presented as trauma activations. Of the 402 patients planned for nonoperative treatment, 192 (48%) had post-mobilization imaging. Zero patients demonstrated radiographic occult pelvic instability, demonstrating that post-mobilization films are not useful. Three of these 192 patients had significant difficulty with mobilization, and underwent surgical stabilization. In all 3 of these cases the post-mobilization films were read as minimal or no displacement and chart notes specifically indicated the reason for surgery was based on the patient's pain.

Conclusion: Routine post-mobilization imaging for patients with predicted stable pelvic injuries is not necessary. Of 1057 patients, we found zero with radiographic occult pelvic instability. Eliminating this radiographic step would result in lower cost and decreased patient exposure to radiation. Instead, orthopaedic surgeons should base the need for further diagnostic imaging on uncontrolled pain with mobilization.

Reduction Quality After ORIF of Acetabulum Fractures: Surprisingly Low Interobserver and Intraobserver Reliability

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Purpose: Matta previously described a method for rating the quality of reduction of acetabular fractures on radiographs. While this system has been widely adopted and is prevalent throughout the literature, there is a paucity of evidence on its reproducibility. Given the importance of an anatomic reduction on functional and radiographic outcomes, an accurate and reliable system for assessing intraoperative quality of reduction is essential. The purpose of this study was to examine the interobserver and intraobserver reliability of this system when utilized with intraoperative fluoroscopy in order to validate this assessment technique.

Methods: This is an IRB-approved evaluation of a prospectively collected acetabular fracture database from a single orthopaedic trauma surgeon at a Level I trauma center. The quality of reduction of all acetabular fractures treated with open reduction and internal fixation (ORIF) between May 2013 and December 2015 was assessed using 3 standard intraoperative fluoroscopic views (AP and two 45° oblique Judets). Displacement of ≤1 mm was considered an anatomic reduction, 2-3 mm imperfect, and >3 mm poor. A total of 132 acetabular fractures were treated with ORIF during that time period. 21 patients were excluded for incomplete intraoperative fluoroscopic imaging and 4 patients were excluded for acetabular or femoral hardware that obscured the acetabulum on imaging, leaving a total of 107 (81%) patients available for analysis. Acetabular fracture reductions were reviewed by the operative surgeon at time of surgery and subsequently reviewed by 2 fellowship-trained pelvic/acetabular surgeons. All reduction assessments were performed in a blinded fashion. The primary outcome measure was interobserver reliability for assessing reduction quality. This was evaluated using a weighted kappa (κw) statistic between each reviewer and the operative surgeon and a generalized kappa (κg) for all 3 surgeons. After a 6-week "washout interval," the surgeons reviewed the images again and intraobserver agreement was calculated using a κw statistic.

Results: Interobserver reliability based on the initial assessment was low (κg = 0.09); however, it did slightly improve at the time of the second assessment to fair (κg = 0.24). Individual interobserver reliability between the operative surgeon and each other surgeon was also slight (κw = 0.08 and 0.11). Intraobserver reliability ranged from slight (κw = 0.20) to moderate (κw = 0.53) among the surgeons.

Conclusion: The widely used system described by Matta for assessing reduction quality of acetabular fractures demonstrated low interobserver and intraobserver reliability when used intraoperatively by fellowship-trained pelvic/acetabular surgeons. Further studies are necessary to validate this finding, but these results suggest that a more reliable system may be necessary for the evaluation of the quality of reduction of acetabular fractures following ORIF to aid in achieving an anatomic reduction.

See pages 401 - 442 for financial disclosure information.

Pelvic and Acetabulum Fractures – Which Functional Outcome Measure Should We Use? An Analysis of Responsiveness Over the First Year of Recovery

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Purpose: Pelvic and acetabulum fractures are complex injuries. The best clinical outcome tools to use in research related to these injuries remain largely unstudied. A recent systematic review found a lack of validity and responsiveness testing with pelvic-specific instruments. For generic health scores, the Short Form-36 (SF-36) and Short Musculoskeletal Function Assessment (SMFA) have been used in pelvic and acetabular fracture research, but no comparison of the responsiveness of the 2 in this population has been done. The purpose of this study is to compare the responsiveness of SF-36 PCS to SMFA DI in pelvic/acetabular fracture patients over the first year of recovery.

Methods: 465 patients with pelvic or acetabulum fractures were recruited at a Level I trauma center between 2005 and 2015. SF-36 PCS and SMFA DI were collected prospectively at baseline, 6 months, and 12 months. Responsiveness was evaluated with the standard response mean (SRM), proportion of patients that achieved MCID, and ceiling and floor effects. Paired t tests were used to compare SRMs, and McNemar's test was used to compare the proportion of patients experiencing MCID in SF-36 versus SMFA. Statistical significance was set at a $P < 0.01$.

Results: The mean ISS was 14.3. Mean age was 44.2 years. SF-36 PCS and SMFA DI showed strong correlation for all time intervals. The SRM of SF-36 PCS was significantly greater than the SRM of SMFA DI between baseline and 6 months ($P < 0.0001$) and nearly so between 6 and 12 months ($P = 0.06$). The proportion of patients achieving MCID in SF-36 PCS was greater than in SMFA DI between baseline and 6 months (82.24% vs 69.74%, $P < 0.0001$). Between 6 and 12 months, more patients met MCID with SF-36 PCS (60.53% vs 55.59%), but did not reach significance. There were no ceiling or floor effects found for SF-36 PCS at any time point. The SMFA was found to have a floor effect at baseline (17.82%), and consistently had higher floor estimates at each time point than the SF-36 PCS, but not greater than 10%.

Conclusion: This study demonstrates that the SF-36 PCS is a more responsive measure of functional outcome than the SFMA DI in patients with pelvic and acetabulum fractures, despite the theoretical advantage of a musculoskeletal-specific measure. This superiority was found in using the SRM, proportion of patients meeting MCID, and floor effects. These findings support the isolated use of the SF-36 PCS as the best general functional outcome measure in patients with pelvic and acetabulum fractures, while limiting the burden for both the patient and clinician.

Indications for Angiographic Embolization for Pelvic Fracture: Hypotension and Severe Fracture Pattern Are Better Predictors than CT Blush

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Purpose: Eastern Association for Surgery of Trauma guidelines recommend contrast extravasation (CE) on pelvis CT, also known as CT blush, to be an indication for angiography regardless of hemodynamic status. There is much debate whether CT blush is an accurate predictor of clinically relevant arterial bleeding.

Methods: Persistent hypotension (defined as systolic blood pressure [SBP] <90 mm Hg), Young Burgess (YB) fracture pattern, mechanism, and presence of CE on pelvic CT scan were noted. Fractures with the most displacement (anterior posterior compression [APC]3, lateral compression [LC]3, vertical shear [VS], and combined mechanical injury [CMI]) were considered severe. Patients with any embolization were compared to those without. Embolization of major (named) vessel was compared to embolization of minor (unnamed) vessel and no embolization.

Results: 189 patients (64% male) with mean age 49.3 years, mean ISS 29.3, and mean Glasgow Coma Scale (GCS) 12.1 were reviewed. 56% had embolization; 35% were of named vessels. No mechanism or pattern was associated with arterial embolization of a named vessel. Mechanisms most commonly resulting in named embolizations were motorcycle crash (47%), industrial (44%), and low-energy falls (44%). Major embolizations were APC3 (59%), LC3 (50%), and APC2 (45%). Hypotension before angiography (odds ratio [OR] 3.36, P = 0.001) was the only significant predictor of embolization. Hypotension before angiography (OR 3.47, P = 0.006), severe YB (OR 2.06, P = 0.04), male gender (OR 1.96, P <0.05), and ISS (OR 1.019, P = 0.066) were independent predictors of embolization of named vessels. In multivariate analysis hypotension (OR 4.67, P = 0.008) and severe pattern (OR 2.14, P = 0.055) were predictors of embolization of named vessels ($r^2 = 0.113$). GCS, age, and CE were not significant in any model.

Conclusion: Hypotension and severe YB fracture pattern (APC3, LC3, VS, or CMI) were predictors of named vessel embolization. Although the odds of needing embolization were significantly increased for hypotension (4.67) and severe fracture pattern (2.14), the model explained only a fraction of the variation ($R^2 = 0.113$). CE showed no relevance. Emphasis on clinical judgment of hemodynamic stability and fracture pattern rather than CT findings could reduce unnecessary angiography.

See pages 401 - 442 for financial disclosure information.

The Value of 3D-Printed Models and Virtual Reality in Understanding Acetabular Fractures

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Purpose: Acetabular fractures are complex and difficult to classify. Although the Judet-Letournel classification is designed to increase the understanding of acetabular fractures, it remains prone to error when using conventional medical imaging. We hypothesize that 3-dimensional (3D) printing and virtual reality (VR), as new diagnostic imaging tools, will lead to an increased understanding and knowledge about the acetabular fracture and surgical approach.

Methods: Digital data (DICOM [Digital Imaging and Communications in Medicine]) of 20 acetabular fractures was converted into 3D files (STL [stereolithography] data). These STL files were used to prepare 3D prints of life-size hemi-pelvic models with acetabular fractures and files for a mobile VR headset. Seven senior trauma surgeons specialized in pelvic and acetabular surgery, 5 young fellowship-trained trauma surgeons, 5 senior surgical residents, 5 junior surgical residents, and 5 interns classified 20 acetabular cases using radiographs/2D CT, 3D reconstructions, 3D printing, and VR according to the Judet-Letournel classification. Furthermore, all junior and senior surgeons were instructed to evaluate their surgical approach and positioning of the patient during operation. Time to classify each case was recorded. Calculations were done using Fleiss kappa statistics.

Results: Only slight and fair interobserver agreements for senior surgeons ($\kappa = 0.33$) and interns ($\kappa = 0.16$) were found when using radiographs/2D CT. However, 3D printing showed moderate and substantial interobserver agreements for senior surgeons ($\kappa = 0.59$), junior surgeons($\kappa = 0.56$), senior surgical residents ($\kappa = 0.66$), junior surgical residents ($\kappa = 0.51$), and interns ($\kappa = 0.61$), while VR showed a clear decrease in interobserver agreements for senior surgeons ($\kappa = 0.42$). Compared with radiographs/2D CT, the interobserver agreements on the surgical approach for junior surgeons using 3D printed models and VR increased, respectively, $\kappa = 0.04$, $\kappa = 0.23$, and $\kappa = 0.17$. Except for the interns, a significant time difference between radiographs/2D CT and 3D CT - 3D print - VR was found for junior and senior surgical residents and junior and senior surgeons ($P < 0.001$).

Conclusion: 3D printing is of added value in understanding, classification, and surgical evaluation of acetabular fractures, whereas VR is of added value for the future generation trauma surgeons. We recommend implementation of 3D printed models and VR into trauma surgery training.

The Short and Long-Term Trajectory of Recovery Following Acetabulum Fracture

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Purpose: Acetabular fractures are major injuries that are associated with prolonged disability. Multiple stakeholders including the patient, surgeon, insurers, and hospital administration have an interest in the expected recovery following surgery. Although many publications describe outcomes and risk factors for poor prognosis, none, to our knowledge, map the trajectory of recovery following this injury. The purpose of this prospective cohort study is to outline the trajectory of recovery of operatively treated acetabular fractures from baseline to 5 years from the date of surgery.

Methods: Adult patients with acetabular fractures requiring surgical treatment were recruited to an orthopaedic trauma database at a Level I trauma center between June 2004 and August 2015. Patient-reported functional outcome was recorded using the Short Form-36 Physical Component Summary (SF-36 PCS). Data were collected at baseline, 6 months, 1 year, and 5 years from the date of surgery. Baseline information including age and injury type were recorded. The trajectory was mapped, and the means between time points were compared using paired t tests. The Minimal Clinically Important Difference (MCID) for each group was calculated, and the proportion of patients meeting this mark between each time point was recorded.

Results: The cohort was 148 patients with 56 (38%) simple fractures and 92 (62%) complex fractures. The group was predominately male (121), and had a mean age of 47.1 years. Mean SF-36 PCS scores improved for all patients between 6 and 12 months and between 1 and 5 years from surgery ($P < 0.0001$). Improvement is steep between 6 and 12 months, and continues between 1 and 5 years at a flatter slope. The simple fracture group started at a higher functional level ($P = 0.007$) and are at a higher level after 1 year ($P = 0.008$). However, the complex group sees more improvement in the subsequent 4 years, and the groups are similar at 5 years ($P = 0.7$). Neither group regains their baseline level of function after 5 years ($P = 0.0001$). The MCID changes are also significant in both groups, in that 68% of patients have an MCID change between 6-12 months, and 64% do between 1 and 5 years.

Conclusion: This study demonstrates that patients with surgically treated acetabular fractures experience an initial sharp improvement, followed by steady improvement, in follow-up to 5 years postoperatively. The recovery following simple fracture patterns appears to occur earlier, and both groups end at a similar level. Despite the trajectory of recovery, patients do not return to their premorbid level of function at final follow-up.

See pages 401 - 442 for financial disclosure information.

Native Hip Survival and Long-Term Patient-Reported Outcomes Following Acetabular Fracture

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Purpose: The aim of this study was to report long-term native hip joint survival following acetabular fracture and validated patient-reported outcome measures (PROMs).

Methods: 523 consecutive patients with acetabular fractures from 1988-2010 were included. Mean age was 51 years (range, 14-100) and 356 were male (68%). Management included: open reduction and internal fixation (ORIF) in 210 displaced fractures, 4 acute total hip arthroplasties (THAs), and nonoperative management in 209 undisplaced fractures and in 49 displaced/unreconstructable fractures in the elderly. PROMs (OHS [Oxford Hip Score], iHOT [International Hip Outcome Tool], UCLA) were collected at mean 13.2 years (range, 7.9-28.8) when radiographic review and Kaplan Meier survival analyses were also performed.

Results: 61 patients (12%) underwent late THA at mean 7.5 ± 7.6 years, 174 (33%) had died, and 85 (16%) were lost. With end point THA, 10-year survival was 80.8% (95% confidence interval [CI] 74.5-87.1) after ORIF and 95.4% (92.1-98.7) following nonoperatively managed undisplaced fractures (P <0.001). With severe posttraumatic osteoarthritis or THA as the end point 10-year survival was 79.3% (72.8 to 85.8) and 95.4 (92.1 to 98.7), respectively (P <0.001). PROMs were significantly better in nonoperatively managed undisplaced fractures compared to ORIF: OHS (40.2 ± 12.1 vs 34.8 ± 13.7, P = 0.002); iHOT (78.0 ± 25.0 vs 66.1 ± 30.3, P = 0.01), and improvement in UCLA score (-0.9 ± 2.0 vs -2.2 ± 2.5, P = 0.001). Age was the only significant predictor of outcome following ORIF. Comparing patients <45 and those ≥45 OHS (38.4 ± 13.3 vs 28.7 ± 12.3) and iHOT scores (72.6 ± 28.8 vs 55.0 ± 29.9) were significantly better than in patients <45 years (P <0.001) as was 10-year survival: 86.2% (78.8 to 93.5) compared to 61.4 (48.4 to 74.3) (P = 0.015). Letournel classification, hip dislocation, surgical approach, sciatic nerve palsy, and associated fractures were not significant predictors of outcome or survival after ORIF. Following late THA mean OHS was 35.3 ± 13.0. UCLA activity score fell from median 8 to 5 following ORIF (P <0.001), but 37% returned to preinjury levels. Median UCLA score was unchanged in nonoperatively managed undisplaced fractures. Normal hip function (OHS 100%; iHOT >95%) was reported in 13% after ORIF and 33% of nonoperative undisplaced fractures.

Conclusion: The need for ORIF in displaced acetabular fractures reduces native hip survival significantly compared to nonoperatively managed undisplaced fractures, especially in patients >45 years where long-term patient-reported outcomes are also poorer.

Is There a Critical Window for Debridement of Open Fractures?

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Purpose: The historical "6-hour rule" for time to debridement has been refuted in the literature. Current standards prompt a timely debridement; however, in severe polytrauma, patients are often resuscitated for >24 hours, with delayed orthopaedic intervention. The purpose of this study was to determine the association between prolonged time to operative debridement (>24 hours) and infection, given their unclear association.

Methods: We conducted a retrospective review of patients with non-ballistic open long bone fractures that underwent irrigation and debridement (I & D) from 2008-2016. Demographic variables were collected: age, gender, body mass index, diabetes, smoking, and medications. Injury variables were collected: admission time, injury mechanism, fracture site, Gustilo-Anderson classification, time to antibiotic administration, bone loss, and time in the ICU. Operative variables were collected: time between admission and initial I & D, prophylactic antibiotic, length of initial I & D operation, time to definitive fixation, fixation type, and time to wound closure. Infection variables were collected: time from injury to infection development, cultured bacteria from infection site, and post-infection antibiotics. Chi-squared analysis and logistic regression were performed. P <0.05 was the cutoff for significance.

Results: 657 patients sustained non-ballistic open fractures. 56 (8.5%) developed an infection. Prolonged time to I & D was not associated with increased infection rates (P = 0.25). 44 patients underwent I & D at >24 hours (6.7%; range, 24-296 hours). Two of these patients (4.5%) developed an infection postoperatively, with I & Ds at 31 and 296 hours post-injury. Increased infection risk was associated with Gustilo-Anderson classification (Type 1: 1.4%, Type 2: 6.9%, Type 3: 17.3%; P <0.001), after-hours surgery between 19:00 and 7:00 (odds ratio [OR] = 2.017, P <0.001), definitive fixation >24 hours (OR = 3.099, P <0.001), wound closure >24 hours (OR = 4.406, P <0.001), and >2 operations post-admission (OR = 8.498, P <0.001). Diabetes (P = 0.509), smoking (P = 0.651), and antibiotics received >1 hour post-admission (P = 0.454) were not associated with infection. Number of operations (OR = 4.737, P <0.001) and time to definitive wound closure (OR = 2.782, P = 0.016) were independent predictors of infection by multivariate analysis.

Conclusion: Our data suggest that there is no association between infection and prolonged debridement times. Furthermore, delaying definitive soft-tissue coverage of open wounds may be associated with higher infection rates.

See pages 401 - 442 for financial disclosure information.

Survival Benefit of Physician-Staffed Helicopter Emergency Medical Services (HEMS) Assistance for Severely Injured Patients

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Purpose: In the literature, Helicopter Emergency Medical Services (HEMS) assistance resulted in an increased probability of survival for severely injured patients, especially for those suffering from blunt trauma. However, those studies lack statistical power. The aim of the present study with a longer inclusion period and subsequently a larger cohort size was to determine the effect of physician-staffed HEMS assistance on survival of severely injured patients.

Methods: All consecutive severely injured trauma patients (ISS >15) between October 1, 2000 and February 28, 2013 were included. Assistance of physician-staffed HEMS was compared to assistance from the ambulance paramedic (ie, EMS group) crew only. A regression model was constructed for calculating the expected survival and survival benefit.

Results: A total of 3543 polytraumatized patients with an ISS >15 were treated at the Emergency Department, of whom 2176 patients remained for analysis; 1495 (69%) were treated by EMS only and 681 (31%) patients received additional prehospital care of HEMS. The model with the best fit and diagnostic properties (H-L coefficient 2.959, P = 0.937; area under the curve (AUC) 0.888; positive predictive value [PPV] 71.4%; negative predictive value [NPV] 88.0%) calculated that 36 additional patients survived because of HEMS assistance. This resulted in an average of 5.33 additional lives saved per 100 HEMS dispatches for severely injured patients.

Conclusion: The present study indicates an additional 5.33 lives saved per 100 dispatches of the physician-staffed HEMS. Given the excellent statistical power of the current study (>90%), physician-staffed HEMS is confirmed to be an evidence-based valuable addition to the EMS systems in saving lives of severely injured patients.

Open Tibia and Femur Fractures: Early Antibiotics Minimize Infection with Primary Wound Closure

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Purpose: Early antibiotics and wound coverage have been shown to decrease infection rate in all type 3 open tibia fractures. It is unknown if this is similar in type 1, 2, and 3A open tibia and femur fractures that are primarily closed. The goal of this study is to examine factors decreasing deep infection risk in type 1, 2, and 3A open tibia and femur fractures with primary wound closure.

Methods: We retrospectively reviewed 234 type 1, 2, and 3A open tibia (143) and femur (91) fractures. Exclusion criteria were: (1) <18 years old, (2) delayed >24 hours to operating room, (3) requiring repeat debridement, (4) incomplete data, and (5) negative pressure dressings or other adjunct wound management. Demographics, American Society of Anesthesiologists (ASA) class, mechanism, smoking status, diabetes status, and ISS were included for analysis. Time to first dose antibiotics and time to surgical debridement after injury were taken from the medical record. These were compared using one-way analysis of variance, chi-square, or Fisher exact tests, as appropriate. Binary regression was used to determine if a model could be created that would be predictive of postoperative deep infection as defined by Centers for Disease Control and Prevention (CDC) criteria. Receiver operating characteristic (ROC) curves were then used to identify threshold values.

Results: Age, ASA class, mechanism, smoking, diabetes, and ISS did not predict deep infection rate. Deep infection occurred in 2 of 91 (2.2%) of femur fractures, including 0 of 27 (0%) type 1, 0 of 13 (0%) type 2, and 2 of 51 (3.9%) type 3A. Femur infection rate did not differ by type (P = 0.66). Deep infection occurred in 11 of 143 (7.7%) of tibia fractures, including 0 of 50 type 1 (0%), 6 of 67 type 2 (10.4%), and 5 of 26 type 3A (19.2%). In tibia fractures the infection rate increased with fracture type (P = 0.005). Femur fracture infection rates were significantly lower, regardless of type, compared with type 2 (P = 0.04) and type 3A tibia fractures (P = 0.006). No individual variable besides time to antibiotics predicted infection. Using the threshold value from the ROC curve, infection was 5.9 times more common (odds ratio = 5.9 (95% confidence interval [CI]: 1.7 to 19.8; P = 0.004) in patients with time to antibiotics >154 min (9 of 102, 8.9% vs 4 of 132, 3.0%; P = 0.004).

Conclusion: Time from injury to antibiotics predicts infection in type 1, 2, and 3A open tibia and femur fractures that are primarily closed. This reinforces prior research in type 3 open tibia fractures and suggests a similar effect in open femurs and type 1 and 2 open tibia fractures. Our study suggests that prehospital antibiotics can improve outcomes in all open fractures, regardless of severity.

See pages 401 - 442 for financial disclosure information.

High Acuity Polytrauma Centers in Orthopaedic Trauma: Decreased Patient Mortality and Increased Resource Utilization

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Purpose: There are a select number of massive-volume, high-acuity trauma centers (HACs) in the US. Expertise in polytrauma care has been shown to improve mortality in patients with abdominal injuries and metabolic shock, cardiovascular injury, and liver damage. Along with polytrauma expertise comes the burden of high rates of complications, increased length of stay (LOS) and cost of care, without a commensurate increase in allocated resources. The purpose of this study was to compare mortality, complications, and LOS in polytraumatized patients treated at HACs versus low-acuity trauma centers (LACs).

Methods: The 2014 National Trauma Data Bank was queried for orthopaedic injuries with ISS >15 and mortality, complications, hospital LOS, ICU LOS, ventilation duration, and demographics. Hospitals where at least 13% (the median percentage of patients with ISS >15 admitted to all hospitals) of total admissions had an ISS >15 were classified as HAC; all other hospitals were deemed LACs. Logistic regression was performed to determine association between acuity and outcomes of interest, adjusted for demographic factors and comorbidities.

Results: HACs admitted 86.8% of all 28,314 patients with ISS >15; 13.2% were admitted to LACs. The average age was 46.3 years; 66.6% of patients were male, and 71.2% were Caucasian. Those arriving to HACs have 12% decreased odds of in-hospital mortality than those in LACs (P = 0.048, odds ratio [OR] = 0.88, 95% confidence interval [CI] 0.78-0.99). Patients at HACs have 64% greater odds of ICU admission (P <0.001, OR = 1.64, 95% CI 1.52-1.77), and 48% higher odds of ventilatory support (P <0.001, OR = 1.48, 95% CI 1.37-1.59). Patients admitted to HACs have 41% increased odds of unplanned reoperation (P = 0.044, OR 1.41, 95% CI 1.01-1.96). Patients have a 52% increased odds of medical complications at HACs (P <0.001, OR 1.52, 95% CI 1.37-1.70). In addition, patients at HACs had 2.8 days longer LOS than those at LACs (P <0.001).

Conclusion: Severely injured orthopaedic trauma patients have decreased mortality at HACs, which may be attributable to better anticipation of critical need via ICU admission and ventilator support. The decrease in mortality, however, comes at the financial cost of prolonged ICU-level care and intubation, more surgery, and longer inpatient stays. HACs are optimal destinations for polytrauma orthopaedic patients, although caring for these patients is expensive and reflects poorly on typical hospital metrics.

High Union Rate of Treatment of Adult Aseptic Distal Tibial Nonunions Using Ilizarov External Fixation with Slow Gradual Compression

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Purpose: Distal tibial nonunions can be treated with a variety of surgical techniques. Ilizarov external fixation presents many advantages over conventional internal fixation.

Methods: A retrospective review was performed on a consecutive series of adult patients with aseptic nonunions of the distal third of the tibia treated with Ilizarov slow gradual compression by a single surgeon. Some patients also had deformity correction with or without bone grafting prior to initiating compression. No patient in the current series had a known bone infection, a segmental bone defect that comprised greater than 50% of the available surface contact area between fragments, or was treated with bone transport or excision with acute shortening. Nonunion was defined as a lack of radiographic or clinical signs of progression toward healing for 3 consecutive months and a fracture line that in the opinion of the treating surgeon had zero chance of healing without further intervention.

Results: 94 consecutive adult patients with 94 distal third tibial nonunions comprised our cohort. 87 of 94 cases (92.6%) healed following slow gradual compression across the nonunion site with an Ilizarov external fixator. Four of the 7 patients who failed Ilizarov treatment healed following additional operative treatment and the remaining 3 refused further care. No patient had a deep infection at the nonunion site or an amputation of the involved limb.

Conclusion: Ilizarov external fixation with slow gradual compression was successful in treating aseptic nonunions of the distal third of the tibia in 92.6% of cases. Careful selection of patients for this treatment method can lead to a high success rate with a low complication rate.

See pages 401 - 442 for financial disclosure information.

Outcome After Treatment of Elbow Stiffness Following Bicolumnar Fixation of Distal Humeral Fractures

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Purpose: Intra-articular fractures of the distal humerus are typically treated with bicolumnar plate fixation. Despite prompt and accurate reduction and fixation, many patients have postoperative complications of stiffness, hardware prominence, and ulnar neuropathy. Such patients often undergo subsequent elbow release and hardware removal. The purpose of this study was to determine the indications, technique, and outcomes of this reconstructive procedure.

Methods: Patients who had undergone an elbow release with hardware removal by a single surgeon following bicolumnar fixation of an intra-articular fracture of the distal humerus were identified. Patients were contacted to participate in a chart review, and to return for a follow-up visit. Patients who returned for a follow-up visit completed the DASH (Disabilities of the Arm, Shoulder and Hand) and the MEPS (Mayo Elbow Performance Score).

Results: 50 patients were included in the final analysis. The mean age of patients at the time of the elbow release was 44.3 years, the average time from the original injury to the time of release was 18.4 months, and 52% of the patients were male. Stiffness was the most common indication for operative intervention (n = 41), followed by hardware prominence (n = 22), ulnar neuropathy (n = 21), and heterotopic ossification (n = 9). In 45 patients (90%), both plates were removed, and in 5 patients (10%) only 1 plate was removed. There was a statistically significant improvement in the flexion-extension arc measured prior to the elbow release and hardware removal (mean = 64°), and measured at the last follow-up (mean = 93°), P <0.001. 15 patients completed the DASH questionnaire and the mean score was 21 (SD = 19). The mean value for the MEPS was 82 (SD = 16), indicating good function of the elbow. Complications included posttraumatic osteoarthritis (n = 27), ulnar neuropathy (n = 12), and heterotopic ossification (n = 11). There were 4 reoperations (8%): 2 patients had a revision release of contracture and 2 patients underwent a closed manipulation. One patient underwent a total elbow arthroplasty (TEA), and one patient sustained a refracture of the distal humerus.

Conclusion: It is safe to re-intervene relatively early, and in general removal of both plates is recommended. There is a modest but consistent improvement in flexion-extension arc, and the reoperation rate is low. Although there is a high rate of posttraumatic arthritic change, TEA was rare, and elbow-based outcome scores were good, although not normal.

The Effect of Metabolic and Endocrine Disturbances on Fracture Nonunion

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Purpose: Fracture nonunion leads to decreased quality of life for patients and high financial costs to the patient and the health-care system. Both mechanical and metabolic factors play an important role in fracture healing. Previous reports document high rates of metabolic disturbance in nonunions that have otherwise received appropriate surgical/nonsurgical treatment. The goal of this study is to define the rate of metabolic disturbance in all long bone nonunions treated at a single Level I trauma center over a period of 6 years. We hypothesize that the rate of metabolic disturbance in patients with nonunion will not differ based on adequacy of initial treatment.

Methods: A retrospective chart review was performed of billing and coding records identifying patients who underwent operative intervention for nonunion from January 2010-December 2016. Exclusion criteria included age <18 years, treatment by non-trauma faculty, and planned, staged bone grafting of segmental defects. 111 out of 166 patients identified from billing records met inclusion criteria. These 111 patients were placed into 2 groups based on the adequacy of the initial treatment. Data analysis included demographics, nonunion site, assessment of initial fracture treatment quality, and metabolic/endocrine laboratory values (calcium, thyroid-stimulating hormone, free T4, Vitamin D, magnesium, phosphorus, testosterone, and alkaline phosphatase).

Results: In our nonunion cohort of 111 patients, 78% of patients had an undiagnosed metabolic or inflammatory laboratory abnormality. There was no statistically significant difference among fracture nonunions with adequate mechanical stability versus inadequate stability (P = 0.6). Among the patients deemed to have inadequate mechanical stabilization a total of 76% of patients (16 of 21) demonstrated an undiagnosed abnormality in their testing versus 79% of patients (71 of 90) in the patients deemed to have adequate mechanical stability. As a result of testing, 59% of patients had their treatment plans changed.

Conclusion: These data demonstrate a relatively high rate of metabolic disturbance in patients with long bone nonunions. Furthermore, we found no significant differences between rates of metabolic disturbance based on adequacy of initial treatment. We recommend metabolic screening for all patients with fracture nonunions, not simply those without mechanical reason for nonunion.

See pages 401 - 442 for financial disclosure information.

Circumferential Bone Graft Around an Absorbable Gelatin Sponge Core Reduced the Amount of Grafted Bone in the Induced-Membrane Technique for Critical-Size Defects of Long Bones

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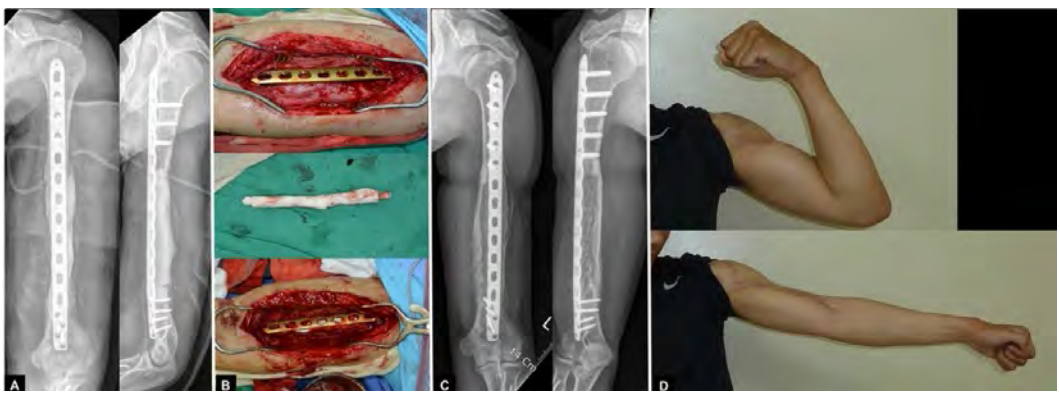
Purpose: The aims of the study were to introduce a circumferential bone graft around an absorbable gelatin sponge core using induced-membrane technique, to assess its ability to reduce the required amount of graft, and to maintain the bone graft.

Methods: This was a retrospective review of prospectively collected data at a urban university medical center. The central core of defect was filled with absorbable gelatin sponge. The gel foam core was surrounded with the harvested autogenous bone like a shell. The serial 3-dimensional (3D) model was configured by virtual 3D software to verify if the circumferential bone graft could be maintained properly. The volumetric measurements of defect size, proportion of gelatin sponge, and amount of grafted bone was done. The resorption of grafted bone were calculated comparing each serial CT scan and 3D model to verify if the circumferential bone graft could be incorporated well.

Results: The critical-size defect was located at the metadiaphyseal area of 11 tibias, 8 femurs, and 2 humeri. The average defect size was 8.9 cm in length and 65.2 cm^3 in volume. The absorbable gelatin sponge core replaced 21.4% (average) of the defect volume. There was no significant deterioration in the shape of grafted bone between serial 3D models. 18 patients (86%) were healed radiographically at 9.1 months.

Conclusion: Our study suggests that circumferential bone grafting in association with induced-membrane technique could reduce the required amount of bone graft and adequately maintain graft position and shape, with favorable clinical results.



The Results of Membrane-Induced Osteogenesis in Posttraumatic Bone Defects

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Purpose: It is absolutely challenging to treat posttraumatic bone defects surgically. Masquelet has reported that membrane-induced 2-step operation can accelerate osteogenesis in the zone with bone defects. We are performing membrane-induced osteogenesis for patients suffering from posttraumatic bone defects. Here, we are going to analyze the results of their treatment and also the effects of the operation.

Methods: From January 2014 until June 2016, among the patients having bone defects for a resection done in the process of getting treatment for posttraumatic osteomyelitis, we selected 54 subjects who had received treatment with membrane-induced osteogenesis and had been observed for over 1 year. Here, retrograde analysis was conducted. We cultured the tissue before removing the dead tissue from the zone with bone defects or debriding the tissue infected for osteomyelitis, and then, we cultured the tissue again after the debridement in order to evaluate the appropriateness of the treatment. We filled the antibiotic-loaded cement spacer in the zone with bone defects to form an induced membrane and repeated the debridement until the tissue culture was found to be negative. After treating the infection clinically, we operated the bone graft.

Results: During the 2 years of study, 54 patients were bone grafted and average bone defect was 82 mm. Tibia shaft cases were most common as 19 cases and second was femur shaft cases. 37 cases presented single organism on cultural study, most common was methicillin-resistant *Staphylococcus aureus* (MRSA) for 11 cases followed by Pseudomonas for 7 cases. 6 cases presented multiple organisms. Most common was MRSA for 4 cases, when calculating each microorganism individually. 11 cases showed no organism at all. In total, MRSA was 25% of all cases and no organism was second most common with 18% rate. Bone union without infection recurrence were 47 cases, and 1 of the cases showed donor site infection. Infection recurrence occurred at 7 cases, 4 among them were cured with revision surgery, 2 are being treated, and only 1 case ended up amputation of lower extremity. None of the cases showed same culture result compared to previous original organism. Primary success rate was 87% and secondary 94.4%.

Conclusion: Three-stage induced-membrane technique can be a good choice for treatment of bone defect due to posttraumatic osteomyelitis. It is also useful for treating bone defects accompanied with infection.

See pages 401 - 442 for financial disclosure information.

Osseointegrated Implants for Transfemoral Amputees: Radiographic Evaluation of Bone Remodeling

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Purpose: Osseointegration is a novel method to overcome persistent socket prosthetic issues in amputees by anchoring a transcutaneous implant directly onto the skeletal residuum. Although similar technologies have been widely applied in the area of hip and knee arthroplasty, little evidence exists in the literature reporting the bone remodeling effects of osseointegrated implants. Stress shielding results in the reduction of bone density due to the implant removing the stress that is usually exerted on the bone, which greatly reduces implant stability. This study investigates the bone remodeling effect and quantifies it in 2 of the most common osseointegration implants.

Methods: This is a prospective study of 50 patients with transfemoral amputations, consisting of 35 males and 15 females, aged 20-73 years (mean 48.2) at surgery, with minimum 2-year follow-up. Two implants, the Integral Leg Prosthesis (ILP) and Osseointegrated Prosthetic Limb (OPL), with differences in tapering, coating and bone ingrowth regions, were examined. Radiographs were taken at 6 months, 1 year, 2 years, and 5 years post surgery. The surrounding bone was defined using inverse Gruen zones and graded into 5 levels of bone growth or resorption.

Results: Results obtained at 1 and 2-year follow-ups were compared to the 6-month follow-up values as a baseline. Significant bone growth near the proximal zones of the implant was observed on patients with the ILP implant. This was accompanied by significant resorption toward the distal end indicating the occurrence of stress shielding. The OLP implant demonstrated much more uniform bone density throughout the length of the implant.

Conclusion: Overall, the patterns of bone remodeling after osseointegration showed similarities to those seen on hip stems with a press-fit design. Of the 2 osseointegration implants examined in this study, the OLP implant exhibited less stress shielding effects and is expected to provide better long-term stability.

Bone Marrow Aspirate Concentrate with Cancellous Allograft Versus Iliac Crest Bone Graft in the Treatment of Long Bone Nonunions

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Purpose: Fracture nonunion results in substantial disability. Iliac crest bone autograft (ICBG) has been considered the standard; however, ICBG provides limited quantities and can be associated with donor site morbidity. Given these limitations, bone marrow aspirate concentrate (BMAC) may be a viable alternative. The primary aim of this study was to evaluate the efficacy of BMAC in achieving nonunion healing compared to ICBG.

Methods: A retrospective matched cohort study was performed on 51 patients. 26 patients with nonunions with defects >2 mm were treated with open repair and BMAC grafting. These patients were matched by age and defect size to 25 patients treated with open repair and ICBG. Treatment success was defined as union, and treatment failure as either requiring revision surgery or progressing to persistent nonunion. Bivariate statistical analysis was performed using Student t tests or Mann-Whitney U tests for continuous variables, and chi-square tests or Fisher's exact tests for categorical variables where appropriate. A time-to-event analysis was done, using the cumulative incidence function, comparing the time to treatment success (bony union) between the 2 groups.

Results: Successful union occurred in 78% of the ICBG cohort, and in 75% of the BMAC cohort (P = 0.8). The median time to union among treatment successes was 3.5 and 5.7 months for BMAC and ICBG, respectively (P = 0.023). In a time-to-event analysis, treatment with BMAC was not a statistically significant factor. Infection was the only risk factor of statistical significance for failure. Open fracture, vascular injury, the need for soft-tissue coverage, and defect size did not influence the chance of failure.

Conclusion: Both ICBG and BMAC demonstrated comparable union rates in the treatment of nonunions. In this study, use of BMAC was associated with a faster time to union when compared to ICBG. While the time-to-event analysis for time to final union was not statistically significant, the difference in time to union between the 2 cohorts may be clinically significant and may result in an earlier return to activity in the BMAC group, although further study is necessary in this regard. The comparable success rate, quicker time to union, and minimal donor site morbidity associated with BMAC supports the use of BMAC in the treatment of long bone nonunions.

See pages 401 - 442 for financial disclosure information.

Surgical Management of U/H Type Sacral Fractures: Outcomes Following Iliosacral and Lumbopelvic Fixation

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Purpose: U and H-type sacral fractures are underdiagnosed injuries resulting from significant axial loading that are often associated with neurological deficits. Two methods of surgical management of these injuries involve the use of iliosacral screw fixation (ISF) and lumbopelvic fixation (LPF). However, there are no studies that have directly compared outcomes from the 2 procedures. The aim of the current study was to examine the surgical outcomes of patients undergoing ISF or LPF for U/H type sacral fractures.

Methods: The current study is a retrospective analysis of patients that underwent surgical fixation of a U or H type sacral fracture from 2004-2015 at one Level I trauma center. 16 patients met our inclusion criteria, 8 of whom underwent ISF and 8 underwent LPF. The average age of patients was 46.5 years (range, 16-80) with a mean follow-up of 13.9 months (range, 1-52). Surgical outcomes were compared using an unpaired Student t test or a Fisher exact test where appropriate.

Results: The majority of these fractures (9) were classified as type 2 using the Roy-Camille classification system. Six patients had the presence of a neurological injury at the time of presentation, 9 had concurrent spine fractures, and 10 had concurrent pelvic fractures. The majority of fractures occurring from a high-energy mechanism occurred in patients younger than 41 years of age, while all injuries occurring as a result of a ground level fall occurred in those over 64 years of age. There was no significant difference between the 2 groups with regard to age, ICU requirement, length of stay, or estimated blood loss (EBL). However, if those patients who underwent ISF and additional pelvic fixation were removed from analysis there was a significant difference in EBL ($P = 0.01$). In addition, there was a significant increase in surgical time in the LPF group ($P = 0.002$), likely reflecting the concurrent sacral decompression that was performed in 7 of 8 patients. Finally, there was a significant increase in those patients who underwent ISF who were discharged to a rehabilitation facility compared to those treated with LPF ($P = 0.04$).

Conclusion: Patients with U/H type sacral fractures can be treated with ISF or LPF without an expected increase in hospital length of stay or need for ICU. Treatment with LPF may increase operative time and EBL if it is an isolated sacral injury. However, the ability for immediate weight bearing in the LPF group results in an increased likelihood of patient discharge to home instead of a rehabilitation facility.

Elevated INR Is Associated with Epidural Hematoma in the Setting of Thoracolumbar Spinal Trauma

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Purpose: Very little literature exists examining thoracic and lumbar epidural hematomas caused by trauma. Scoring systems have been introduced to guide treatment recommendations in the setting of thoracic and lumbar spine trauma. The presence of an epidural hematoma was not included in these systems, although oftentimes it is a factor in treatment considerations. Some epidural hematomas are associated with spinal cord or dural sac compression and may necessitate surgical decompression. The objective of our study is to determine the incidence and associated risk factors for epidural hematoma in the setting of thoracic and lumbar spine trauma.

Methods: IRB approval was obtained prior to conducting this study. We performed a retrospective review of all traumas at our institution between 2010 and 2014. Patients with ICD-9 codes for T1 to L5 fractures were further investigated. Patients <18 or >90 years old, or without MRI were excluded. Patients who had thoracic and/or lumbar epidural hematoma (TLEH) were compared to those who had no epidural hematoma (NEH). A subgroup analysis of the TLEH arm was performed, based on the presence (CC) or absence (NCC) of cord or dural sac compression due to epidural hematoma. Age, gender, race, admitting international normalized ratio (INR), and ISS were compared between groups.

Results: Of 1810 trauma patients, 1185 patients were identified with thoracic or lumbar fractures, of which 511 subjects had MRI available for review. 59 patients (4.9%) were found to have a posttraumatic thoraco-lumbar epidural hematoma. Age, gender, and race were found to be similar in both analyses. More patients with INR ≥1.5 were found in the TLEH group (10.2% vs 2.9%, P <0.05). In the subgroup analysis of the TLEH group, cord or dural sac compression (CC) was seen in 25 patients for an incidence of 4.9%. When comparing risk factors, the CC group had more patients with INR ≥1.5 (20% vs 2.9%, P <0.05) than the NCC group.

Conclusion: The incidence of thoracic and lumbar spinal epidural hematoma following trauma was found to be 4.9% in our study, of which 4.9% presented with spinal cord or dural sac compression. We found that the greater the INR was in the setting of spine trauma, the higher the risk of spinal epidural hematoma. Additionally, patients with TLEH who had higher INR levels had increased chances of having dural sac compression. Age, gender, race, or admitting ISS had no effect on the incidence of epidural hematoma.

See pages 401 - 442 for financial disclosure information.

Operative Versus Nonoperative Management of Civilian Gunshot Wounds to the Spinal Cord

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Purpose: Surgical indications for spinal cord injury from gunshot (GSCI) are controversial. Functional Independence Measure (FIM) scores for neurologic recovery have not been reported. The purpose of this study is to analyze complications and functional outcomes after GSCI and to compare surgical and nonsurgical management for injuries that did not require surgical decompression or stabilization.

Methods: The trauma registry at an urban Level I trauma center was queried for isolated GSCI between 2006 and 2015. Complications, length of stay (LOS), FIM scores, and FIM gains were determined.

Results: 104 patients were identified—67 complete GSCI and 37 incomplete. For complete GSCI, 16 (24%) had surgery. Mean follow-up was 26.9 months. Baseline characteristics were similar between surgical (SX) and nonsurgical (NSX) groups except higher median ISS in the NSX group (34 vs 27; P = 0.02). No differences in complication rates were noted. For complete GSCI, LOS was longer for SX (52 vs 42 days; P = 0.04), with no difference in FIM scores (58 vs 54; P = 0.7). For incomplete GSCI, 7 patients (19%) underwent surgery. For incomplete GSCI, rehabilitation LOS was longer for SX (35 vs 21 days; P =0.02) with trend for longer LOS (40 vs 32 days; P = 0.07). FIM scores were no different (61 vs 62; P = 0.9).

Conclusion: Surgery for GSCI is associated with longer LOS and no differences in complications or FIM scores for patients with either complete or incomplete spinal cord injuries. The majority of patients with GSCI may be safely treated nonoperatively, as surgery has greater treatment costs without measured clinical benefit.

Table 1. Outcome measures for patients with **complete spinal cord injury** from gunshot wounds

	Surgery (n=16)	No Surgery (n=51)	P value
Intensive Care Unit LOS	10 (1,23)	4 (2,13)	0.4
LOS Hospital	21 (7,26)	9 (4,21)	0.2
LOS Rehab	39 (21,65)	29 (10,39)	.05
Total LOS	52 (40,87)	42 (22,61)	**0.04***
Ventilator Days	1 (0,21)	1 (0,10)	0.7
Chest tube placed	10 (63%)	27 (53%)	0.5
Pneumo/Hemothorax	10 (63%)	25 (49%)	0.3
Lung Injury	11 (69%)	32 (63%)	0.7
Complications			
Cardiac	2 (13%)	4 (8%)	0.6
Pulmonary	9 (56%)	22 (43%)	0.4
Deep vein thrombosis or pulmonary embolus	2 (13%)	4 (8%)	0.6
Decubitus ulcer	7 (44%)	10 (20%)	0.05
Non-surgical infection	5 (31%)	7 (14%)	0.1
Trauma readmit	1 (6%)	5 (10%)	0.9
Acute kidney injury	0	3 (6%)	0.9
Urinary tract infection	10 (63%)	24 (47%)	0.3
Ileus	3 (19%)	5 (10%)	0.4
Dural leak	1 (6%)	1 (2%)	0.2
FIM total			
Rehab admission	26 (20,34)	25 (22,29)	0.7
Rehab Discharge	58 (45,66)	54 (43,63)	0.7
FIM Gain	25 (19,30)	26 (15,37)	0.9

Table 2. Outcome measures for patients with **incomplete spinal cord injury** from gunshot wounds

	Surgery (n=7)	No Surgery (n=30)	P value
Intensive Care Unit LOS[1]	4 (2,5)	3 (1,5)	0.2
LOS[1] Hospital	8 (5,18)	7 (4,14)	0.7
LOS[2] Rehab	35 (28,41)	21 (13,35)	**0.02***
Total LOS[1]	40 (35,53)	32 (23,42)	0.07
Ventilator Days	0 (0,2)	1 (0,2)	0.5
Chest tube placed	2 (29%)	8 (27%)	0.9
Pneumo/Hemothorax	2 (29%)	8 (27%)	0.9
Lung Injury	3 (43%)	11 (37%)	0.9
Complications			
Cardiac	1 (14%)	4 (13%)	0.9
Pulmonary	1 (14%)	4 (13%)	0.9
Deep vein thrombosis or pulmonary embolus	1 (14%)	3 (10%)	0.9
Decubitus ulcer	2 (29%)	1 (3%)	0.09
Non-surgical infection	1 (14%)	4 (13%)	0.9
Trauma readmit	1 (14%)	3 (10%)	0.9
Acute kidney injury	0	0	-
Urinary tract infection	3 (43%)	10 (33%)	0.7
Ileus	1 (14%)	8 (27%)	0.7
Dural leak	1 (14%)	1 (3%)	0.3
FIM[2] total			
Rehab admission	24 (23,36)	27 (23,36)	0.9
Rehab Discharge	61 (48,71)	62 (55,70)	0.9
FIM[2] Gain	30 (19,38)	33 (18,44)	0.5

Long-Term Results and Quality of Life After Thoracoscopic Anterior Stabilization for Thoracolumbar Fractures in Patients Without Spinal Cord Injury

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Purpose: In patients with severe traumatic thoracolumbar fractures, an insufficient load bearing capacity might require anterior stabilization in addition to posterior fixation. Traditional autologous bone grafts come with specific disadvantages such as increased operating time, donor site morbidity, nonunion, and fracture of the strut graft. A distractible titanium cage prevents these disadvantages and combined with anterolateral plating provides stability, maintains kyphosis correction, and prevents posterior implant failure. Minimally invasive thoracoscopy reduces approach-related morbidity but studies on thoracoscopic anterior stabilization are scarce and often report radiological and functional outcomes. Health-related quality of life (QOL), however, is an important outcome that has not yet been reported for this type of surgery.

Methods: This was a retrospective cohort study of patients treated between 2004-2012 in a university Level I trauma center. Patient and treatment characteristics were collected from the hospital information system. All available radiographic material was assessed for fracture characteristics and kyphosis at consecutive times. Patients were asked to fill in the Short Form-36 (SF)-36 and EuroQol (EQ)-5D QOL questionnaires at follow-up.

Results: Of 105 patients who were treated with a distractable cage, the procedure was performed thoracoscopically in 86 cases, including 16 patients with spinal cord injury. Of 70 eligible patients, 46 were available for follow-up and filled in the questionnaires. QOL was lower on most domains compared to the general population. Compared to patients who underwent only posterior fixation for less severe fractures, QOL did not differ significantly. The complication rate was low (10%), with 1 reoperation. The mean loss of correction was 6,8° and bony fusion on CT scan was present in 98% of patients at follow-up. The maintenance of kyphosis correction was significantly better for 2-segment anterolateral plating compared to 1 segment.

Conclusion: Thoracoscopic anterior stabilization with a distractable cage leads to a high percentage of bony fusion in highly unstable thoracolumbar fractures with limited loss of reduction and no hardware failure. Health-related QOL of these patients does not return to normal population values but is comparable to that of patients with less severe fractures treated with only posterior instrumentation. The procedure is technically safe with no reinterventions needed due to cage dislocation or implant failure and has a low complication rate.

See pages 401 - 442 for financial disclosure information.

Rapid Increase in the Rates of Vertebral Fracture Repair Surgeries in the United States from 2006 to 2014

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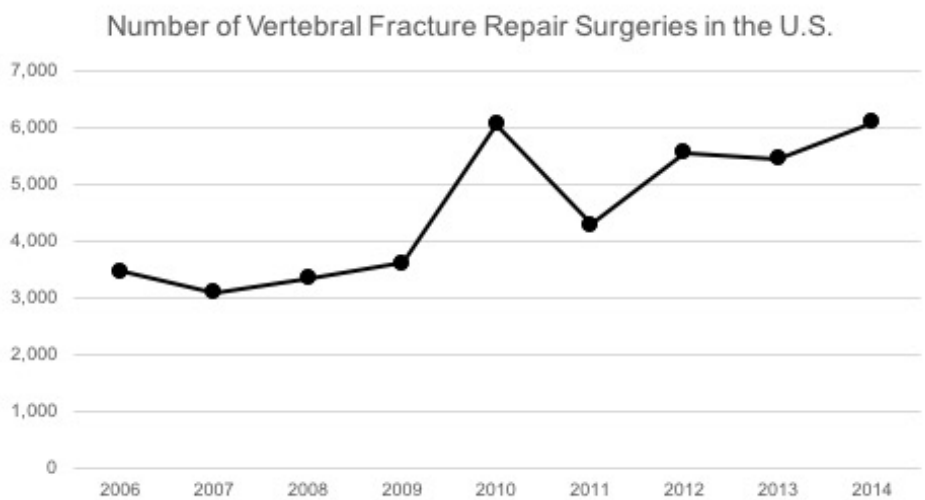
Purpose: The primary hypothesis of this study is that the annual volume of surgeries performed for vertebral fractures (VFX) has increased over the 9 year study period.

Methods: The National Inpatient Sample (NIS) database was analyzed for the operative treatment of VFX from 2006-2014. Outcome data were determined for the procedure based on the ICD-9 CM code 03.53, which includes all operative treatment of vertebral fractures except kyphoplasty and vertebroplasty.

Results: An estimated 40,877 VFX repair surgeries were performed in the United States from 2006-2014. The number of procedures per year increased 76% during the course of the study period with a mean of 4542 surgeries per year (range, 3085-6085). Mean LOS decreased 30% over the same period with a yearly LOS mean of 12.0 days per patient (range, 9.3-13.9 days). The mean percentage of patients with routine discharge was 39% (range, 34-46%). The mortality rate of operative intervention for VFX was 2.5% (range, 1.9-3.3%). The cost of VFX repairs increased 5.2% overall (mean: $47,235; range, $42,104-$52,884). Charges have increased 50.3% over the study period (mean: $163,147; range, $116,507-$188,897).

Conclusion: Operative management of vertebral fractures has increased by 76% in the U.S. from 2006-2014 to 6,085 surgeries per year in 2014. LOS has decreased by 30% over the same time period, and yet both costs and charges have increased. On average 61% of patients were either discharged to a skilled nursing facility or had home nursing.



Quantitative Functional Recovery After Closed Tibia Fracture

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Purpose: We sought to evaluate functional recovery after surgical repair of isolated, closed tibial shaft fractures using an objective measure over several visits. We also compared our results to functional deficits seen in a prior study that observed a similar cohort who had undergone fasciotomies. We hypothesize that the majority of recovery occurs soon after injury and that fasciotomy delays functional recovery.

Methods: Study participants had isolated, unilateral, closed tibial shaft fractures. Isokinetic assessment was performed at 3, 6, and 12-month follow-up visits. We calculated peak torque/body weight (T) as a percent and total work (W) in ft-lbs bilaterally for each patient, measuring ankle dorsiflexion (D) and plantar extension (P) at both 60° and 120° per second. We compared functional outcomes in the injured legs to the function of the healthy legs at each time point and longitudinally. We also compared functional recovery in our sample to a similar study with patients who had undergone fasciotomies.

Results: There was a significant difference between healthy and injured leg at 3 months for all metrics except D120W. At 6 months, all metrics were significant except D120T and P120W. At 12 months no metric showed a significant difference. Analysis of longitudinal recovery showed significance between follow-up time and functional recovery between 3 and 6 months for P60WD ($P = 0.004$), P120TD ($P < 0.001$), and P120WD ($P < 0.001$), between 6 and 12 months for D120TD ($P = 0.035$) and P60WD ($P < 0.001$), and between 3 and 12 months for all variables except D60WD ($P = 0.069$) and D120WD ($P = 0.656$). A significant effect throughout the study period was found for all metrics except D60WD ($P = 0.075$) and D120WD ($P = 0.469$). Functional recovery at 12 months was greater for our cohort than for patients who underwent fasciotomies in addition to tibia fracture repair in a separate study. All metrics other than P60T ($P = 0.175$), P120T ($P = 0.054$), and P120W ($P = 0.055$) were significantly different between groups.

Conclusion: The difference in function between healthy and injured legs decreased over time according to a paired t test, with equivalent function by 12 months. Longitudinal analysis came to a similar conclusion. Plantar flexion improved more rapidly than dorsal extension. At 12 months, our non-fasciotomy patients had significantly greater improvement in strength compared to a study with similar patients who underwent fasciotomies. This confirms that fasciotomy itself may independently delay functional recovery following tibial fracture.

See pages 401 - 442 for financial disclosure information.

Effect of Mental Health Conditions on Complications, Revision Rates, and Readmission Rates Following Tibial Shaft, Femoral Shaft, and Pilon Fracture

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Purpose: Few studies have evaluated the effect of comorbid mental health (MH) conditions on revision surgery, postoperative complications, and hospital readmission. The purpose of this study was to evaluate the effect of preexisting MH conditions on these metrics following tibial, femoral, and pilon fracture.

Methods: Data were collected using the commercially available PearlDiver software (national database of Humana and Medicare-insured patients) for which CPT codes were used to identify patients who underwent surgical treatment of a tibial, femoral, or pilon fracture. These patients were then subdivided into those with and without preexisting MH condition using ICD-9 codes. Anxiety, depression, chronic pain syndrome, fibromyalgia, bipolar, posttraumatic stress disorder, schizophrenia, and psychosis were included in the analysis. 90-day postoperative complications, revision surgery, and 30-day readmission rates were then compared between those with and without MH conditions.

Results: Total number of patients for tibial, femoral, and pilon fractures, respectively, included 6625, 4353, and 4510 without MH conditions and 7009, 7041, and 3912 with MH conditions. Tibial, femoral, and pilon fracture 90-day readmission rates, respectively, were 7.8%, 27%, and 9.6% without MH conditions and 15.7%, 37%, and 12.4% with MH conditions ($P < 0.0001$). Revision rates for tibial, femoral, and pilon fractures, respectively, were 1.4%, 1.7%, and 0.8% for those without MH conditions and 2.9%, 2.8%, and 2.2% for those with MH conditions ($P < 0.0001$). Complication rates including death, deep vein thrombosis, wound dehiscence, cerebrovascular accident, mechanical complication of implant, and complex regional pain syndrome were significantly higher among patients with MH disorders. Subgroup analysis excluding patients with schizophrenia, posttraumatic stress disorder, and bipolar disorder did not affect readmission rates, complications, or revision rates.

Conclusion: In an environment of cost savings, bundled payments, and risk stratification, it is important to note that the presence of comorbid mental health conditions is associated with higher postoperative complications, readmission rates, and revision surgery for tibial, femoral, and pilon fractures.

To Monitor, or Not to Monitor: That is the Question?

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Purpose: The link between fractures of the tibial diaphysis (TD) (AO/OTA 42.A-C) and acute compartment syndrome (ACS) is well established. However the diagnosis of ACS can be challenging and therefore some advocate use of continuous compartment pressure monitoring (CCPM) to aid the diagnosis. The aim of this study was to evaluate whether use of CCPM significantly increased the rate of decompression fasciotomies in patients who had sustained a TD fracture.

Methods: We retrospectively reviewed the management of all patients who were admitted with a fracture of the TD across 3 centers during a 2 year period. Two hospitals routinely managed these patients with clinical observation alone whereas one center chose to supplement clinical examination with CCPM. Therefore, the study cohort was logically divided depending on their place of admission into monitored (MG) and non-monitored (NMG) groups. Information regarding patient demographics, surgical management, subsequent complications, methods of compartment monitoring, and follow-up were all included in the data collection. Statistical significance was assumed when $P < 0.05$.

Results: A total of 287 patients were included in this study (116 NMG vs 171 MG). There were no significant differences observed in the patient demographics between the groups. The majority of patients had AO/OTA type 42.A1-3 fractures, that were treated with an intramedullary (IM) nail (89% MG, 57% NMG; $P = 0.001$). The average time from admission to surgery was 28 hours for the MG compared to 24 hours for the NMG; this difference was not significant ($P = 0.92$). 21 patients were treated for a suspected ACS (n = 13 MG, n = 8 MG) and were treated with acute decompression fasciotomies. Of these patients, 100% of the MG were treated with IM nailing, compared to 63% of NMG ($P = 0.058$). Of these patients some developed ACS pre-fracture fixation; as a result they had fasciotomies combined with surgical fracture management. These patients received their treatment on average 16 hours (MG) and 18 hours (NMG) from admission. Of the patients who developed ACS postoperatively, these patients received their fasciotomies on average 19.5 hours (MG) and 21.25 hours (NMG) from admission.

Conclusion: This study illustrates that CCPM does not increase the rate of fasciotomies in patients who have suffered a TD fracture when compared with standard clinical assessment. Further prospective research is required to clarify the diagnostic utility of CCPM and to assess the subsequent impact on clinical and functional outcomes in patients who develop ACS.

See pages 401 - 442 for financial disclosure information.

Segmental Tibia Fractures: They Don't Stand Alone

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Purpose: Segmental tibial fractures are usually the result of high-energy trauma. Reports specifically including these fractures typically include relatively few cases. The purpose of this study is to determine the most commonly associated injuries and complications of patients sustaining segmental tibial shaft fractures.

Methods: A retrospective review of all segmental tibial shaft fractures that presented to 2 Level I trauma centers between 2005-2013 was performed. The radiographs of these patients were reviewed. The minimum time for follow-up for inclusion was 12 months. The eligible patient charts were analyzed for patient demographics, presence of comorbidities known to affect bone healing, mechanism of injury, fracture details, surgical procedures, and complications. Outcome variables that were analyzed include union rate, average time to union, and the need for additional surgeries to promote healing.

Results: Approximately 3300 tibia fractures were treated during the study period. 108 patients met the inclusion criteria. All fractures were AO Type 42C2. 73 patients (67%) sustained open fractures, while 34 patients (31%) had compartment syndrome. The mean ISS was 29 (range, 4-75). No patient experienced an isolated tibia fracture. 95 patients underwent intramedullary nailing of the tibia, 4 underwent open reduction and internal fixation, and 2 patients were definitively treated with external fixation. 8 patients (7%) underwent amputations. Of the 73 patients who sustained open fractures, 24 (32%) underwent reamed intramedullary nailing of the tibia with primary wound closure at the time of initial operative intervention. Three patients required flap coverage of their open wounds. The mean length of hospital stay was 13 days (range, 3-48). The mean time to union was 27 weeks (range, 14-48). The delayed union rate was 43%; the nonunion rate was 9% (9 of 100). In those patients with open fractures, the patient's diabetes status, body mass index, and smoking status were not statistically significant factors with time to union ($P = 0.19$, $P = 0.28$, and $P = 0.47$, respectively). Additionally, the presence of compartment syndrome and the location of the fracture pattern for open fractures were also not significant in union rate ($P = 0.06$ and $P = 0.92$, respectively).

Conclusion: We present the largest series of patients with segmental tibia fractures. Our study demonstrated that these fractures are not isolated injuries and these are multitrauma patients with a mean ISS of 29. There is a high rate of open fractures and compartment syndrome. Patients should be appropriately counseled regarding the nature of this injury and complications.

Suprapatellar Versus Infrapatellar Intramedullary Nailing of Distal Tibia Fractures: Is There a Difference in Alignment?

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Purpose: This study was performed to evaluate angular malalignment after intramedullary nailing (IMN) of distal tibia fractures (AO/OTA 43 type fractures) using either a suprapatellar (SP) or infrapatellar (IP) approach. Prior studies have shown increased malunion rates following IMN of distal tibia fractures using an IP approach compared to plating. It was hypothesized that malalignment rates of distal tibia fractures treated with IMN would be decreased with use of an SP compared to an IP approach.

Methods: Between January 2010 and January 2015, all patients who underwent IMN for AO/OTA 43 type fracture were retrospectively reviewed and screened for inclusion. Inclusion criteria were skeletal maturity and AO/OTA 43 type fractures. Those with simple intra-articular fracture extension were included but those that required open reduction and internal fixation of the tibial plafond were excluded. Other exclusion criteria included previous injury and/or deformity. Standardized intraoperative and immediate postoperative AP and lateral radiographs were reviewed for alignment in the coronal and sagittal planes. Angular malalignment was defined as ≥5° in either plane. Chi-squared and simple t tests were used for evaluation of categorical and mean data, respectively.

Results: 350 patients were screened for inclusion. 69 patients met inclusion criteria: 47 men and 22 women. 33 underwent IMN of their distal tibia fracture through an IP approach and 36 through a SP approach. Valgus was the most common deformity in the coronal plane, occurring in 11 patients (16% of all nails). The likelihood of valgus deformity was lower in the SP group than the IP group (8.3% vs 23.5%, P = 0.08). Recurvatum was the most common deformity in the sagittal plane, occurring in 7 patients (10% of all nails) and was equally likely using either approach (11.1% in SP nails vs 11.8% of IP nails, P = 0.93). More patients had fibula fixation in the SP group versus the IP group (51.6% vs 17.6%, P = 0.008); however, there was no correlation between fibula fixation and malalignment.

Conclusion: Distal tibia fractures nailed through an SP approach have improved coronal alignment compared to an IP approach. Although not reaching statistical significance, the data in this study demonstrate a clear trend towards this finding. Based on these results, IMN via SP approach may improve overall alignment in distal tibia fractures. A multicenter, prospective randomized trial may provide a definitive answer to this question.

See pages 401 - 442 for financial disclosure information.

Early Functional Performance Is a Valid Predictor of Outcome After Tibia Fracture

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Purpose: Healing after fracture is typically assessed by conventional radiographic imaging. However, radiographs are an ambiguous indicator for healing and for functional performance. Evaluation of gait has been suggested as an early predictor of healing outcome. This prospective case series was conducted to test the hypothesis that early assessment of functional weight bearing after tibial shaft fractures predicts healing outcome at 12 months after fracture.

Methods: In a prospective case series, 20 patients with tibia/fibula shaft fractures (42-A and 42-B) who were surgically treated with an intramedullary nail were included and 15 (11 male, 33 ± 12 years; 4 female, 47 ± 19 years) have completed the 12-month follow-up. Patients' functional loading on the affected leg was measured 12 weeks post surgery during knee-bending on a force plate. Walking was quantitatively assessed in an instrumented gait laboratory. Analysis was focused on kinematics about the knee measured in the frontal plane. Healing outcome was assessed by Short Musculoskeletal Function Assessment questionnaire (SMFA) and the Radiographic Union Scale for Tibial Fractures (RUST).

Results: Functional loading at 12 weeks was a good predictor for functional performance ($R = -0.73$, $P = 0.001$) and everyday activity ($R = -0.60$, $P = 0.01$) at 12 months. Four patients had reduced weight bearing at 12 weeks (34% vs 53%, $P < 0.001$) and demonstrated unphysiological loading of the knee joint with increased valgus moment and reduced knee flexion ($P < 0.01$). Radiographs at 12 weeks demonstrated incomplete healing in 14 of 15 patients with an average RUST score of 7 ± 2. At the final follow-up at 12 months after surgery, the 4 patients with reduced loading at 12 weeks had a significantly reduced function score (18 ± 7 vs 7 ± 5, $P < 0.01$) and everyday activity score (19 ± 13 vs 5 ± 5, $P < 0.01$). In contrast, the RUST score at 12 weeks was not associated with any of the outcome parameters at 12 months after fracture ($P > 0.2$).

Conclusion: Our findings suggest that functional loading of a fractured limb at 12 weeks after injury is highly predictive of the healing outcome at 1 year. Patients unable to place at least 50% body weight on their affected leg 12 weeks after surgery remain to have limitations in their function and everyday activity until up to 12 months after their accident. Gait analysis suggests these functional limitations to be associated with gait imperfections and unphysiologic loading. In conclusion, functional analyses could help in early identification of functional deficits, and could potentially indicate therapeutic intervention to prevent functional deficits.

Intramedullary Nailing of Tibial Shaft Fractures with an Intact Fibula: Is This a Fracture at Risk for Nonunion?

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Purpose: Numerous risk factors for tibial shaft fracture nonunion have been established; however, the role of an intact fibula on union rates in tibial shaft fractures when treated with intramedullary nailing (IMN) remains controversial. The purpose of this study was to determine the incidence and cofactors of delayed healing in middle- and distal-third tibial shaft fractures treated with IMN, in the setting of an intact fibula.

Methods: This study was a retrospective review of patients with middle- and distal-third tibial shaft fractures with intact fibula treated at our institution by IMN over a 10-year period. Data collection included a chart review assessing patient demographics, with image review to characterize fracture pattern, construct of locking screw and nail patterns, fracture stability, and radiographic healing. Delayed union was defined as fractures ununited 6 months after the index procedure. Nonunion was defined as fractures ununited greater than 9 months post index procedure.

Results: A total of 974 patients were treated with IMN for tibial shaft fractures. 74 patients (7.6% incidence) presented with a tibial shaft fracture with an intact fibula. 42 patients (57%) met our inclusion criteria. Four patients (9.5%) developed an established nonunion, and 9 patients (21.4%) exhibited delayed union, for a total of 13 patients (31%) with abnormal healing. Use of a single distal locking screw was found to be a risk factor for nonunion ($P = 0.024$, risk ratio [RR] 11.3). Use of 2 medial to lateral only distal locking screws was associated with healing issues ($P = 0.021$, RR 8.6). A nonsignificant trend toward valgus ($P = 0.089$) and apex anterior ($P = 0.091$) malreduction was seen in all cases of abnormal healing. No significant change in alignment was seen between the initial postoperative images and final follow-up images of patients with abnormal healing. There were no significant differences in healing times and union rates between middle- and distal-third tibial shaft fractures. No differences were noted regarding open fractures, or with respect to fracture orientation. The average time to weight bearing was not significantly different between patients with union and patients with abnormal healing (an average of 39 and 47 days, respectively). Average time to union was 14 weeks in patients with normal healing. Patients with delayed union united at an average of 34 weeks while nonunions healed an average of 50 weeks following index procedure.

Conclusion: Isolated tibial shaft fractures remain a challenge. Medial to lateral only distal locking screws and single distal locking screws were significantly associated with abnormal healing. Use of fewer and medial-entry only locking screws likely allow cantilever bending through the intact fibula due to a less stiff construct. There was a trend toward valgus and apex anterior malalignment among delayed unions, reinforcing the importance of anatomic reduction of these fractures. Consideration for biplanar distal interlocking and adjunct measures for anatomic reduction should be strongly encouraged.

See pages 401 - 442 for financial disclosure information.

Risk Factors for Failure of Surgery to Promote Bone Healing for Tibia Nonunions and Acute Cortical Defects: A New Preoperative Risk Assessment Score

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Purpose: The purpose of the present study is to develop a clinically useful prediction model of success at the time of surgery to promote bone healing for tibia nonunion or staged traumatic bone gaps.

Methods: The study group consisted of adult patients treated either for tibia fracture nonunion or staged bone grafting for traumatic bone defects at a single Level I trauma center from 2007-2016. A literature review yielded 27 potential independent variables thought to be associated with delayed healing of fractures and were therefore investigated. Patients were included if they had a minimum 12 months follow-up or were deemed healed via an evaluator blinded to outcome using the Radiographic Union Score for Tibia Fractures (RUST). The primary outcome measure was failure of the surgery to promote bone healing. Our cohort consisted of 203 patients who underwent surgery for nonunion (n = 143) or traumatic bone defects (n = 60). Chi-squared and Student t tests were used to examine bivariate relationships. Multivariate logistic models were developed using backward stepwise regression, removing covariates with P values >0.2.

Results: Multivariate logistic modeling identified 5 significant risk factors for failure of the surgery to promote bone healing: (1) mechanism of injury (MOI), (2) body mass index (BMI), (3) cortical defect size (mm), (4) flap size (cm^2), and (5) insurance status. Using the 5 significantly associated risk factors a predication scoring model was created. Within this prediction model, MOI was afforded the highest point totals: 0 points for fall, 15 points for high-energy blunt trauma, 20 points for industrial/other, and 31 points for ballistic injuries. 1 point is given for every 10 cm^2 of flap size, 10 mm of mean cortical gap distance, and 10 units BMI, respectively. 3 points are awarded for Medicaid or no insurance and 2 points for Medicare. When risk score was regressed on the binary revision surgery measure, each 1-point increase in risk score was associated with a 6% increase in odds of having at least 1 revision surgery (P <0.001) with an area under the curve (AUC) of 0.77 indicating reasonable performance of the prediction model.

Conclusion: The present study presents a clinical score that predicts the likelihood of success following surgery for tibia fracture nonunions or traumatic bone defects. This score might be used in clinical practice to help guide surgical decisions and help set appropriate patient expectations.

Unhelmeted Motorcycle Riders Have Increased Injury Burden: A Need to Revisit Universal Helmet Laws

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Purpose: Motorcycle crashes continue to become increasingly more common as the number of motorcyclists grows rapidly. However, the universal helmet laws, which were first enacted in 1967, have recently been repealed by many states. Currently, only 19 states observe the universal helmet laws requiring all motorcyclists to wear a helmet, 28 states have laws only requiring some motorcyclists to be protected by a helmet, and 3 states have no motorcycle helmet laws. The objective of this study is to compare hospital data for patients who were in a motorcycle collision and the outcomes associated with helmet wear.

Methods: The National Trauma Data Bank was utilized to conduct a retrospective analysis of 10,345 patients who were classified as having a motorcycle crash (MCC). Available inpatient data was analyzed on variables including hospital length of stay (LOS), ICU admission, ventilation support, insurance status, Glasgow Coma Scale (GCS), ISS, and mortality (on arrival and inpatient).

Results: Patients were divided into 2 groups: those wearing a helmet (n = 6250) and those who were not (n = 4095). Patients not wearing a helmet had an increased risk of: admission to the ICU (odds ratio [OR] = 1.36, P <0.001, confidence interval [CI] 1.25-1.48), requiring ventilation support (OR = 1.55, P <0.001, CI 1.39-1.72), presenting with a GCS of 8 or below (OR = 2.150, P <0.001, and inpatient mortality (OR = 2.00, P <0.001, CI 1.58-2.54). Unhelmeted patients were more likely to have government insurance or be uninsured than those patients wearing a helmet (P <0.001).

Conclusion: It is not well understood why many states are repealing or have repealed universal helmet laws. Lack of helmet use increases the severity of injury in traumatized patients leading to a substantial financial impact on health-care costs. Our analysis suggests the need to revisit the issue regarding laws that require protective headwear while riding motorcycles due to the individual and societal impact.

See pages 401 - 442 for financial disclosure information.

Do Health-Care Disparities Affect Outcomes Following Nonunion Repair Surgery?

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Purpose: Socioeconomic disparities are an inherent and unavoidable aspect of medicine. Knowledge of these disparities is an essential component of medical decision-making, particularly among an increasingly diverse population. While health-care disparities have been elucidated in a wide variety of orthopaedic conditions and management options, they have not been established among patients who present for treatment of an ununited fracture. The purpose of this study is to determine if socioeconomic and educational disparities exist, following nonunion repair surgery.

Methods: Over a 12-year period, operatively treated patients who presented with a long bone fracture nonunion were prospectively followed. Sociodemographic factors were recorded at presentation. Functional outcomes were evaluated using the Short Musculoskeletal Function Assessment (SMFA). Univariate analysis was performed using Student t tests for continuous variables and chi-squared analysis for dichotomous variables. Analysis of variance was used when comparing means between ethnic groups. Multiple linear regression analysis was performed with the dependent variable being SMFA at long-term follow-up and independent variables being age, sex, race, income, and education level.

Results: 294 patients met inclusion criteria. Patients with a lower education (high school graduate or less) had worse long-term functional outcomes ($P < 0.001$) and increased pain scores ($P = 0.006$) at latest follow-up. Patients who made less than $50,000 annually had worse long-term functional outcomes ($P = 0.001$) and reported higher pain scores ($P = 0.003$) following nonunion repair. Multiple linear regression demonstrated education level to be an independent predictor of long-term functional outcomes following nonunion repair ($B = .269$, 95% confidence interval [CI] = 5.722 to 15.452, $P < 0.001$). No differences existed in outcomes or pain scores between those of different racial groups.

Conclusion: Patients with lower education levels and individuals who make less than $50,000 annually have worse functional outcomes following long bone nonunion repair. Orthopaedic trauma surgeons should therefore be aware of these disparities and consider early interventions aimed at optimizing patient recovery in these subsets.

A Deep Neural Network Improves Fracture Detection by Clinicians

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Purpose: Some clinicians lack the subspecialized expertise necessary to identify fractures on radiographs, resulting in missed fracture detection rates as high as 15%. Recent advances in deep learning have produced computer models that learn by example and are effective at many visual identification tasks. Because the models learn by example, subspecialized experts can in principle teach them to detect pathologies by labeling large datasets of radiographs. We hypothesized that (1) a trained algorithm's diagnostic accuracy may be comparable (area under the curve [AUC] ≥0.90) to that of experienced orthopaedic surgeons and (2) a deep learning model taught to detect fractures would improve the diagnostic accuracy of less experienced clinicians.

Methods: To create training examples for the model, 18 senior subspecialized orthopaedic surgeons identified and localized fractures in 135,409 radiographs. We developed and trained a deep neural network model on the radiographs, and we tested its ability to identify fractures on two datasets of wrist radiographs from an academic hospital. We then tested 21 urgent care attending physicians and physician assistants using a within-subjects design to evaluate their diagnostic accuracy with and without the assistance of the model.

Results: On the 2 test sets used for model evaluation, the model's diagnostic accuracy as measured by the area under the receiver operating characteristic curve (AUC ROC) was 0.97 and 0.98. With the assistance of the model, the average urgent care clinician's sensitivity increased from 79.0% to 90.1% (2-sided Wilcoxon signed rank test, P <0.0001, Cohen's d = 1:14) and specificity increased from 85.9% to 94.5% (P <0.0001; d = 1:42). The average clinician experienced a relative reduction in misinterpretation rate of 52.0% (95% confidence interval [CI], 38.0% - 60.8%). The model achieved 93.9% sensitivity (95% CI, 82.9% - 98.0%), 94.5% specificity (95% CI, 90.9% - 96.8%), and .990 AUC (95% CI, .975 - .996) on the same radiographs.

Conclusion: We have demonstrated that a machine learning algorithm trained on a large dataset can produce a fracture detector that outputs heat maps and detects fractures with diagnostic accuracy comparable to experienced orthopaedic surgeons. Because the software takes milliseconds to make an assessment and can run on most computers, it has the potential to significantly reduce the incidence of missed fractures and improve patient care worldwide. When the model's output was provided to urgent care clinicians, their diagnostic accuracy was significantly improved.

See pages 401 - 442 for financial disclosure information.

The Standard Reusable Orthopaedic Depth Gauge: A Pilot Study of Residual Device Contamination Following Routine Cleaning

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Purpose: Surgical site infections (SSIs) are a serious issue in orthopaedic surgery, occurring in up to 4% of cases. One known etiology behind hospital-acquired SSIs is the use of contaminated reusable medical devices, particularly those with designs that make effective cleaning difficult, because proper cleaning is essential for effective sterilization. Several such design features, including rigid lumens and multiple parts, exist in orthopaedic depth gauges, which are routinely used in trauma surgery and regularly exposed to blood, bone, and tissue. The purpose of this study was to measure the cleanliness of orthopaedic depth gauges after standard cleaning and reprocessing.

Methods: Visual and chemical tests of device cleanliness were conducted on a random sample (n = 12) of orthopaedic depth gauges at a highly ranked Level I trauma center after they underwent the center's standard cleaning processes. The devices were visually inspected for soils, which could include rust, blood, bone, tissue, or other debris, with the naked eye and with a lighted, flexible 3.3-mm borescope. The devices were also tested for protein and hemoglobin residue, as well as with a combined test for carbohydrate, protein, and hemoglobin.

Results: Of the devices that were tested, 91.7% (11 devices) failed visual inspection, meaning visual evidence of soils was seen on or within the device. Notably, the small lumen of the device was smaller than the borescope, so it was impossible to visualize and, therefore, could have retained additional debris. Furthermore, 16.7% (2 devices) failed chemical tests for hemoglobin and those same 2 devices tested positive for protein.

Conclusion: Ultimately, all but one of the devices harbored soil. Of greater concern, 16.7% tested positive for protein and hemoglobin residue. These results suggest that the design of the orthopaedic depth gauge makes it challenging to clean properly. US Food and Drug Administration recommendations state that sterilization may not be effective if a device cannot be adequately cleaned. Moreover, other orthopaedic instruments with poorly cleaned lumens have caused serious infections. New methods to improve the cleanliness of depth gauges should be considered, which could include more effective cleaning protocols, a design that makes cleaning easier, or a single-use, disposable device.

Clinical Outcomes and Complications of the SIGN Intramedullary Nail: A Systematic Review and Meta-Analysis

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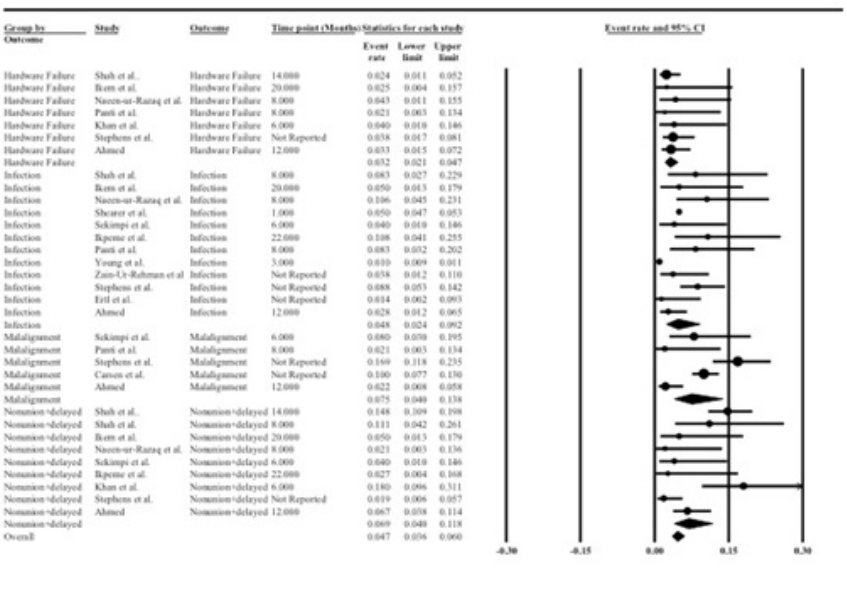
Purpose: The Surgical Implant Generation Network (SIGN) supplies intramedullary nails that can be placed without imaging for the treatment of long bone fractures. This study is a systematic review and meta-analysis of the clinical outcomes and pooled complication rate of femoral, tibial, and humeral fracture fixation using SIGN nails.

Methods: We electronically searched databases from 2000-2016 for English language studies. There was substantial heterogeneity among studies included. Therefore, we employed subgroup analysis of varying adverse events and removal of potential outlier studies in order to address the heterogeneity across studies. We reported pooled complication rates for each adverse event with 95% confidence interval.

Results: There were 14 studies with 47,169 cases across 58 countries. All studies demonstrated >90% full weight-bearing status, range of motion, radiograph union, or clinical union depending on the specific variable measured. The overall complication rate was 5.2% (Fig. 1) with malalignment being the most common complication, followed by delayed/nonunion, infection, and hardware failure.

Conclusion: Overall, the use of SIGN nails in fixing femoral and tibial shaft fractures demonstrates good results with a high rate of return to full weight bearing and radiographic union. Complications include malalignment, delayed/nonunion, infection, and hardware failure. Future areas of development may be able to target these challenges.



See pages 401 - 442 for financial disclosure information.

Utilization of the Dedicated Orthopaedic Trauma Room for Open Tibia and Femur Fractures: Does It Make a Difference?

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Purpose: This review was conducted to determine the effect of the dedicated orthopaedic trauma room (DOTOR) on the management and outcomes of open tibia and femur fractures.

Methods: A retrospective review was performed to identify patients with open tibia and femur fractures managed between 2006 to 2011 at our rural academic Level 1 trauma center. Patients were divided into those managed in the DOTOR and those managed in the on-call operating room (OCOR). Data points collected included: patient demographics, ISS, mechanism of injury, operating room parameters including time to operative debridement, and patient outcomes such as union, malunion and infection rates, unplanned operations, and amputation.

Results: 297 patients with 347 open tibia and femur fractures were identified. 154 patients with 174 open tibia and femur fractures were in the DOTOR group and 143 patients with 170 fractures were in the OCOR. The average time to initial operative debridement was significantly longer in the DOTOR group (12 hours and 57 minutes) when compared to the OCOR group (5 hours and 22 minutes). The DOTOR group was 9 times less likely to undergo debridement within 6 hours. Both groups had a similar number of patients debrided within 24 hours (90% DOTOR vs 96% OCOR). The DOTOR group had a significantly higher rate (73.2%) of primary fracture union (56.6% OCOR). The OCOR group was twice as likely to have an unplanned surgery. Rates of infection, nonunion, and amputation were similar.

Conclusion: Over 5 years, a similar number of patients were treated for open tibia and femur fractures in the OCOR and the DOTOR. Fractures managed in the OCOR were 9 times more likely to undergo initial operative irrigation and debridement within 6 hours. Despite early access to the operating room, there was no difference in rates of infection and the OCOR patients were twice as likely to have an unplanned surgical procedure. On the other hand, fractures managed in the DOTOR were twice as likely to go on to uncomplicated fracture union.

Frailty Predicts Mortality and Complications in Young Patients with Traumatic Orthopaedic Injuries

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Purpose: Frailty is a marker of decline across multiple systems. A modified frailty index (MFI) that incorporates comorbidities and functional status has been validated as a predictor of complications and mortality in elderly orthopaedic patients; studies in young patients are limited. The purpose of this study is to evaluate frailty as a predictor of mortality and postoperative complications in young patients with pelvis and lower extremity trauma.

Methods: The National Surgical Quality Improvement Program (NSQIP) database from 2008-2014 was queried for all patients with pelvis, and lower extremity trauma. To calculate the MFI, 11 variables are summated, including diabetes, congestive heart failure, hypertension, myocardial infarction, cerebrovascular accident, vascular disease, functional status, chronic obstructive pulmonary disease, prior percutaneous coronary intervention, cardiac surgery, and impaired sensorium. The MFI is calculated by dividing the number of variables present by the total number of variables. From prior studies, the threshold between "fit" and "frail" was determined to be an MFI of 0.25 with 0.4 as the threshold for dependence on activities of daily living. Patients were classified into non-frail (MFI = 0-0.2), moderately frail (MFI = 0.2-0.36), and severely frail (MFI >0.36). Patients were divided into elderly (age ≥60 years) and young (age <60). Multivariate logistic regression determined 30-day mortality. Secondary outcomes include Clavien-Dindo grade 4 complications.

Results: This study included 15,787 young patients, and 40,634 elderly patients. Young patients were: non-frail (90.5%), moderately frail (9%), and severely frail (0.52%). Elderly patients were: non-frail (60.6%), moderately frail (36.2%), and severely frail (3.3%). Across all ages, there is a stronger association between MFI and 30-day mortality (odds ration [OR] 11.02, 95% confidence interval [CI] 6.25-19.39) than age and 30-day mortality (OR 1.07, 95% CI 1.06-1.07) (P <0.001). Regression showed no interaction between MFI and age in predicting mortality(P = 0.384). Rate of Clavien-Dindo complications increased from 1.18% at MFI 0 to 11.06% at MFI 0.36+. An increase in MFI is associated with a 28.8 times increased odds of Clavien-Dindo complications (95% CI: 16.05-51.77, P <0.001).

Conclusion: The utility of frailty indices in young patients has been debated, with studies demonstrating validity for predicting complications and mortality. In this series of orthopaedic trauma patients, the MFI predicts mortality and complications better than age alone. This indicates that MFI is valid in all age groups, and can be utilized to direct interdisciplinary management in all orthopaedic trauma patients.

See pages 401 - 442 for financial disclosure information.

Incidence of Vacuum Phenomenon-Related Intra-Articular or Subfascial Gas Found on CT Scans of Closed Lower Extremity Fractures

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Purpose: Recent work has proposed CT to be a more reliable alternative to the traditional saline load test when evaluating for traumatic arthrotomy, based on the presence or absence of intra-articular air. Vacuum phenomenon (VP), an accumulation of gas pulled out of solution, is a well-known entity primarily occurring within the vertebral column and associated with chronic degenerative changes. This phenomenon has been show to occur, in case reports alone, along with lower extremity fracture. As VP may occur in association with closed lower extremity fractures, this could potentially limit the diagnostic potential of CT in the diagnosis of open fracture. Our purpose was to determine both the frequency at which VP occurs in association with closed lower extremity fractures and which fracture patterns are more likely to display VP.

Methods: A retrospective database review was conducted at a Level I community academic trauma center to identify all patients who sustained a closed fracture of the tibia or femur. Patients were included if a CT scan of the fracture was obtained. Fractures of the proximal femur and any periprosthetic fractures were excluded. After all inclusion and exclusion criteria were applied, a total of 153 patients were included in the final analysis. Age, gender, mechanism of injury, fracture location, and OTA classification were recorded for all patients. All CT scan axial cuts were reviewed to identify the presence or absence of gas.

Results: 27 (17.6%) of the 153 fractures were found to have intra-articular or subfascial gas on CT despite clear documentation indicating a closed injury with no significant skin compromise. Of the intra-articular fractures (OTA 33B/C, 41B/C and 43B/C), 20% (23 of 113) were found to have gas on CT. All cases were associated with fracture of the tibia ($P = 0.002$). OTA type 43-C fractures were statistically significantly more likely to have of presence of gas on CT when compared to other fracture types ($P = 0.0002$).

Conclusion: CT demonstrated the presence of intra-articular or subfascial gas in 17.6% (27 of 153) of closed lower extremity fractures and in 20% (23 of 113) of closed intra-articular fractures. The possibility of vacuum phenomenon must be considered when utilizing this imaging modality as the confirmatory test for open intra-articular fracture or traumatic arthrotomy.

Can the AAOS/OTA Hip Fracture Skills Simulator Improve Your Surgical Skills? Validation of a Computer-Based Force-Feedback Simulation Platform

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Purpose: Interest in surgical simulation in orthopaedic resident training led to the development of a computer based force feedback simulation platform by the AAOS and OTA designed to use modules to teach motor skills associated with percutaneous, fluoroscopically guided procedures. Our hypothesis was that users who complete these modules would out-perform those who did not.

Methods: With IRB approval, 24 medical students, recruited from our institution, were randomized to the Training or Control group. After a basic introduction to the simulator, the Control group performed the task of placing three guide-wires (inverted triangle construct) in a valgus-impacted femoral neck fracture (OTA 31-B1) using the simulator. The Training group completed nine training modules on the simulator prior to performing the same task. Our primary outcome measures, determined based on previous construct validation studies, included: pin distance to three defined ideals on the femoral neck, distance to the femoral head articular surface, and distance to ideal starting point on lateral cortex. Unpaired t tests were used to compare the groups.

Results: The training group significantly outperformed the control group ($p<0.05$) in 7 of the recorded performance metrics, including guide-wire distances to the posterior ($p=0.04$) and anterior ($p=0.04$) joint surface, inferior guide-wire tip to center difference ($p=0.04$), parallelism of all three wires ($p= 0.01$-0.04), and overall score ($p=0.002$). The training group had a marginally significant improvement ($0.05 < p <0.14$) over the control in four measures including guide-wire distance to medial cortex, inferior guide-wire distance to the joint surface, distance from the correct starting point, and distance to the lateral cortex. No observed difference in distance to posterior and anterior cortex and number of re-tries.

Conclusion: This study demonstrates efficacy of the AAOS/OTA Hip Fracture Simulator training modules to allow users to outperform their peers in 7 of 14 measured parameters, implying that the training modules may effectively teach motor and three-dimensional spatial skills associated with fluoroscopically guided percutaneous pinning of a hip fracture. A valid computer based simulation platform capable of teaching such skills has the potential to improve surgical education in orthopaedic trauma.

See pages 401 - 442 for financial disclosure information.

Medicaid Payments for Fracture Repair Surgery Lag Behind Medicare Rates in a National Comparison

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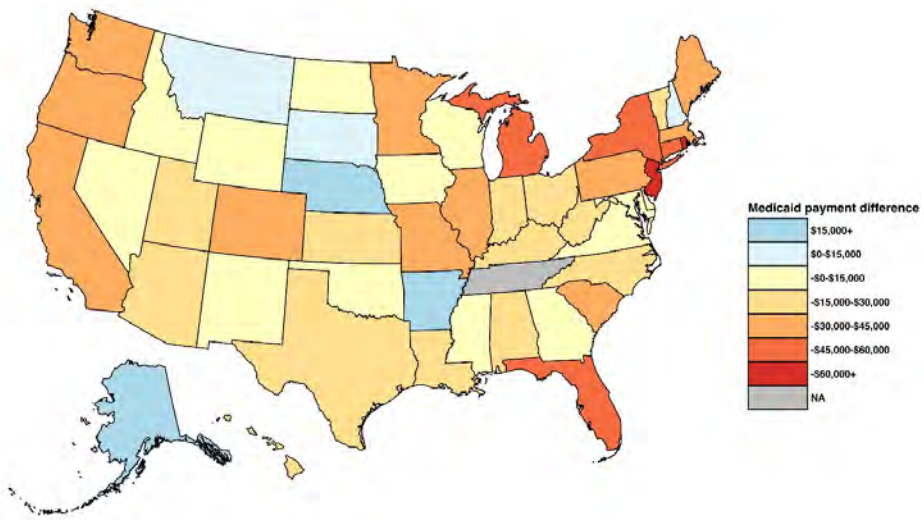
Purpose: Medicaid is the largest health insurer in the US, yet the program is administered on the state level and reimbursement rates are highly variable. Medicare rates provide a robust comparator because they are determined nationally and often serve as a basis for calculating private insurer payments.

Methods: Reimbursements for 10 frequently billed fracture repair surgeries were compared between Medicaid and Medicare in each state. A Medicaid-to-Medicare fee index was calculated to show the percentage difference in reimbursement. An impact analysis demonstrated the gap in total payment between the two payers for 100 surgeries of typical case mix. Medicaid-Medicare fee differences were normalized by work relative value units (wRVUs) to demonstrate variation across procedures in reimbursement per unit of work.

Results: On average, Medicaid rates were 20% lower than Medicare rates with the gap in reimbursement for 100 procedures of typical case mix ranging from -$81,267, in New Jersey, to +$38,663, in Alaska (Figure 1). When fee differences were normalized by wRVUs, there was still wide variation across procedures in the size of the average Medicaid discount. The average Medicaid discount for surgical treatment of proximal humeral fracture was $19 per wRVU, but the average discount for surgical treatment of femoral neck fracture was $12 per wRVU.

Conclusion: The Medicaid-authorizing statute decreed that Medicaid reimburse at rates that are "sufficient to enlist enough providers" to provide equal access to care. Our findings call into question the extent to which reimbursements for operative fracture care are sufficient to ensure equal access in every state.



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-Reported Outcome Measures for Anxiety and Depression Are Correlated with and Predict Physical Function in Patients with Orthopaedic Injuries

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Purpose: The primary goal of this study is to establish the link between physical function and depression/ anxiety/pain interference. To do this we examined whether PROMIS Physical Function (PF) CAT (computer adaptive test) scores are correlated to PROMIS Depression CAT and PROMIS Anxiety CAT scores at three and six month follow-up in orthopaedic trauma patients. The secondary goal is to determine whether scores on the PROMIS Depression CAT and Anxiety CAT at initial clinical follow up can predict low PF CAT scores at final follow-up.

Methods: All patients (2014-2016) at the orthopaedic trauma clinic at our level 1 trauma center are administered the PROMIS Physical Function (PF), Depression (Dep), Anxiety (Anx) and Pain intereference (PI) CATs at all clinic visits. The PROMIS domains are all normalized to the general population with a mean score of 50 points and each standard deviation set to 10 points. After IRB approval, all orthopaedic trauma patients with PRO scores were reviewed from this database; further clinical data was gathered from this source including CPT codes, dates, and clinical treatment variables. Inclusion criteria consisted of a history of an operative fracture and PRO scores at the two week, three-month and six-month clinical visits. Linear regression and Spearman's (S) rank correlation (non-normally distributed numeric variables) were used for bivariate analyses.

Results: Five hundred and sixty two patients met inclusion criteria. Three and six-month follow-up PROMIS PF scores were negatively correlated with three and six-month follow-up PROMIS Dep scores (S -0.468; 95% CI -0.534, -0.396; $p<0.0001$), PROMIS Anx scores (S -0.536; 95% CI -0.596, -0.469; $p<0.0001$) and PROMIS PI scores (S -0.663; 95% CI -0.711, -0.609 $p<0.0001$). A PROMIS Dep score with a value greater than 60 at first clinical visit was predictive of a lower PF CAT and higher Dep CAT score at final follow-up ($p<.0001$). An elevated Anx CAT value at first clinical visit was predictive of both a lower PF CAT score and higher Anx CAT score at final follow-up ($p<.0001$).

Conclusion: Self-reported depression and anxiety are negatively correlated with patient reported physical function at three and six months follow-up. Measuring depression and anxiety in patients at their two week visit identifies patients that may benefit from intervention to treat their anxiety and depression and improve overall function after traumatic injury. Further research into the effect of targeted intervention on these mental health comorbidities is warranted.

See pages 401 - 442 for financial disclosure information.

Health-Related Quality of Life Decreases Following Resolution of Fracture and Fracture-Related Complications

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Purpose: It is clear from previous literature that many patients do not return to full function at 1 year following a tibia fracture. However, less is known about the implications of specific fracture-related complications on a patient's quality of life. The purpose of this study was to describe the preference-weighted quality of life for common complications following tibia fractures. We hypothesized that these measures would improve at 1 year post-injury.

Methods: This is a secondary analysis of 2138 tibia fractures patients enrolled in the FLOW (Fluid Lavage of Open Wounds) and SPRINT (Study to Prospectively Evaluate Reamed Intramedullary Nails in Tibial Fractures) trials. Patients returned for follow-up assessments at 2 weeks, 6 weeks, 3 months, 6 months, 9 months, and 12 months post-fracture. Outcome measures were confirmed by a blinded adjudication committee. Outcome measures include operative complications (compartment syndrome, infection, nonunion, malunion, wound issue requiring flap, wound issue requiring split-thickness skin graft and symptomatic hardware) and nonoperative complications (infection, wound issues). Preference-rated utility values were converted from Short Form-12 (SF-12) or Short Form-36 (SF-36) into SF-6D.

Results: The mean quality-adjusted life years (QALYs) per year following tibia fracture were significantly higher in patients who did not experience a complication compared to those who sustained a nonoperative complication (0.681 [SD 0.122] vs 0.632 [SD 0.126], P <0.001) and to those who sustained an operative complication (0.681 [SD 0.122] vs 0.625 [SD 0.108], P <0.001). All patients demonstrated improvement in utility value from the time of injury to final follow-up. Utility values for patients with a complication were significantly lower than those without a complication at all time points after 6 weeks (P <0.01).

Conclusion: This analysis of 2138 prospectively followed patients with a tibia fracture demonstrates that utility values improve over the year following injury; however, patients who experience complications have significantly lower utility values at 6 weeks, 3 months, 6 months, 9 months, and 12 months, compared to those who do not experience a complication. Furthermore, on average, patients with tibia fracture, with or without complication, do not return to their baseline utility value or to the US age-adjusted norms. This suggests that, while the acute fracture and complications may have resolved clinically, the detrimental effect on a patient's quality of life persists.

Complication Rates Following Removal of Hardware After Fracture Fixation: Is It Really Risk-Free?

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Purpose: Indications for removing orthopaedic hardware on an elective basis varies widely. Although viewed as a relatively benign procedure, there is a lack of data regarding overall complication rates after fracture fixation. The purpose of this study is to determine the overall short-term complication rate for elective removal of orthopaedic hardware after fracture fixation and to identify associated risk factors.

Methods: Adult patients indicated for elective hardware removal after fracture fixation between July 2012 and July 2016 were screened for inclusion. Inclusion criteria included patients with complete medical and radiographic records and at least 3-month follow-up. Exclusion criteria were those patients indicated for hardware removal for a diagnosis of malunion, nonunion, and/or infection. Data collected included patient age, gender, anatomic location of hardware removed, body mass index, ASA (American Society of Anesthesiologists) score, and comorbidities. Overall complications, as well as complications requiring revision surgery, were recorded. Statistical analysis included univariate and multivariate regression analysis.

Results: 391 patients (418 procedures) were included for analysis. Overall complication rates were 8.4%, with a 3.6% revision surgery rate. Univariate regression analysis revealed that patients who had liver disease were at significant risk for complication ($P = 0.001$) and revision surgery ($P = 0.036$). Multivariate regression analysis showed that: (1) patients who had liver disease were at significant risk of overall complication ($P = 0.001$) and revision surgery ($P = 0.039$) and (2) removal of hardware following fixation for a pilon had significantly increased risk for complication ($P = 0.012$), but not revision surgery.

Conclusion: Removal of hardware following fracture fixation is not a risk-free procedure. Patients with liver disease are at increased risk for complications, including increased risk for needing revision surgery following hardware removal. Patients having hardware removed following fixation for pilon fractures also are at increased risk for complication, although they may not require a return trip to the operating room. Finally, removal of pelvic hardware is associated with a higher return to the operating room.

See pages 401 - 442 for financial disclosure information.

The Impact of the Affordable Care Act (ACA) on an Orthopaedic Trauma Service

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Purpose: Our objective was to determine the impact of the ACA on an orthopaedic trauma service at a Level I trauma center.

Methods: We retrospectively analyzed data collected between July 1, 2012 to December 31, 2013 and January 1, 2014 to July 1, 2015. Data were collected for the orthopaedic trauma attendings and fellows who worked at our center during that time period. The data were collected for all operative cases, consultations, and clinic visits and included: payer, professional fee billing, collections, and the number of patients. The data were analyzed using chi-squared analysis. We corrected for changes in patient volume between the 2 time periods by calculating average values per patient.

Results: We saw a significant increase in the percentage of inpatients (IP) and outpatients (OP) with Medicaid post ACA (IP 25% to 40%, OP 13% to 23%) with a corresponding significant reduction in the percentage of uninsured patients and county payers (IP 13% to 1%, OP 5% to 1%). The total number of IPs we treated changed by 43 patients between the 2 periods (NS), while our OP population decreased significantly by 1194 patients (20%). Collections for IPs and OPs combined increased by $41/patient post ACA (-$49/ IP, + $2/ OP). Post ACA, our collection rate decreased by 6% (IP -5%, OP -8%). Medicaid collections decreased by $162/IP and $4/OP, contract collections increased by $183/IP and $22/OP; UCDHS (UC David Health System) insurance had mixed changes, with decreases of $474/ OP/partial risk, and $693/IP/full risk, and increases of $4/OP/partial risk, and $38/ OP/ full risk), while Medicare decreased by $42/IP and increased $40/OP.

Conclusion: One of the goals of the ACA was to increase access to health care. It appears this was successful at our institution as reflected by the shift in our payer mix. However, this shift in insurance coverage was accompanied by a significant decrease in our collection rate, and a decrease in the amount we collected per Medicaid patient. We did collect more money per patient post ACA, but this occurred because of increases in payments for the patients with contracted insurance and OPs with UCDHS insurance. Because we see so many more OP than IPs, the increased payments on the OP side could make up for the decrease in payments for our IPs. However, we saw 20% less OPs post ACA and most of that decrease was patients with contracts and UCDHS insurance. The increase in Medicaid was mirrored by almost the same decrease in self-pay and county payers. Any additional losses of "better" payers in the future and/or further decrease in Medicaid reimbursement would be financially challenging. We conclude that the ACA did allow more patients to access medical care, but was associated with lower professional fee reimbursement for orthopaedic trauma surgeons.

Factors Predictive of Inpatient and Post-Discharge Prescription Opioid Consumption in an Orthopaedic Trauma Population

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Purpose: Understanding factors associated with opioid use may identify patients susceptible to developing dependency. The purpose of this study was to determine factors associated with inpatient and post-discharge opioid use following orthopaedic trauma.

Methods: 235 adult patients treated operatively for fracture with a minimum of 1 overnight hospital stay were reviewed. Inpatient opioid use, discharge prescriptions, and post-discharge opioid consumption for 6 months were documented. Opioids were converted to oral morphine equivalents (OME). Factors analyzed as potential predictors of opioid consumption were: age, sex, race, insurance, employment, medical comorbidities, use of alcohol, tobacco, or narcotics prior to admission, ISS, the presence of a complication, ICU admission, inpatient opioid use, and discharge prescriptions.

Results: 140 men and 95 women mean age 50 years and mean ISS 11 were studied. Mean lengthy of stay (LOS) was 7.2 days, and 24.3% were admitted to the ICU. Inpatient opioid use was associated with younger age (R^2 = 0.0540, P <0.0003) higher ISS (R^2 = 0.1288, P <0.0001), ICU admission (139 vs 68.5, P <0.0020), and baseline tobacco use (107 vs 69.8, P <0.0038). Patients with prior opioid use did not have higher inpatient needs (84.6 vs 90.1 OME). Predictive modeling for inpatient opioid use demonstrated a negative correlation with age and positive with ISS and ICU admission (model R^2 = 0.205; P <0.0001). Discharge prescription was negatively correlated with age and LOS and positive with history of opioid use (adjusted R^2 = 0.0708, P = 0.0002). After discharge males (1593 vs 843 OME, P = 0.02), those who used alcohol (1815 vs 786 OME, P = 0.007), and who received larger narcotic prescriptions at discharge (R^2 = 0.0553, P = 0.0003) consumed more narcotics, with no association with inpatient use, employment or insurance. Modeling predicted post-discharge opioid use to be greater in patients receiving larger prescriptions for narcotics at discharge and those who use alcohol at baseline (adjusted R^2 = 0.073, P <0.0001), irrespective of type and severity of injury.

Conclusion: Younger age, higher ISS, and ICU admission were predictive of greater inpatient opioid use. However, inpatient use and ISS were not associated with post-discharge opioid use. Rather, post-discharge use is higher in patients receiving more narcotics at discharge and in those who use alcohol.

See pages 401 - 442 for financial disclosure information.

Perioperative Surgeon-Family Communication: Is There an Ideal Time?

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Purpose: Studies have shown that perioperative communication is important in reducing anxiety and improving the overall experience of family members waiting for surgical patients. Presently, there is no agreed upon standardized time to deliver updates to families. We aimed to determine the effect of strategic communication with families during the perioperative period on their satisfaction, anxiety, and overall experience. We hypothesized that frequent updates would enhance the satisfaction and decrease the anxiety levels of the family members during the perioperative period.

Methods: All patients undergoing elective and urgent trauma, arthroplasty, and spine orthopaedic procedures were eligible. Patients were excluded if they were under 18 years of age, non-English-speaking patients and/or families, and patients without family members present. Enrolled patients were randomly assigned to a communication pathway. In the control pathway, the surgeons communicated with the family only once near the completion of the surgery. In the intervention group, the family received additional standardized updates via pagers at 3 pivotal moments: (1) Initial skin incision has been made; (2) critical part of the case is completed, and closure is about to begin; and (3) closure is complete, and patient will be transferred to the recovery room when ready. A postoperative survey was administered rating their satisfaction and anxiety levels on a scale of 0-5.

Results: A total of 101 surveys were completed (control: n=51, intervention: n=50). Overall satisfaction did not differ significantly between the groups (control: 4.61 ± 0.786, intervention: 4.68 ± 0.713, $P = 0.654$). The level of anxiety was significantly lower in the intervention group (control: 3.14 ± 1.385, intervention: 2.49 ± 1.474, $P = 0.026$). Satisfaction with updates was significantly higher in the intervention group (control: 3.16 ± 1.848, intervention: 4.47 ± 0.844, $P = 0.0001$). With regard to update frequency, 47.1% of subjects in the control group, versus 10% of subjects in the intervention group, stated that the updates were too infrequent.

Conclusion: The overall level of satisfaction of the family members was independent of the frequency of intraoperative electronic surgical updates. However, anxiety and satisfaction with perioperative updates was significantly improved by additional updates. The results of this study suggest that additional, strategic perioperative updates would improve the experience of family members.

Tranexamic Acid in Orthopaedic Trauma Surgery: A Meta-Analysis

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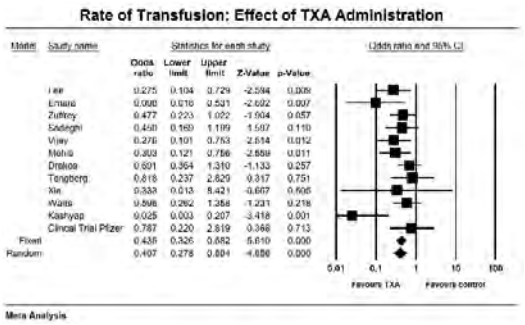
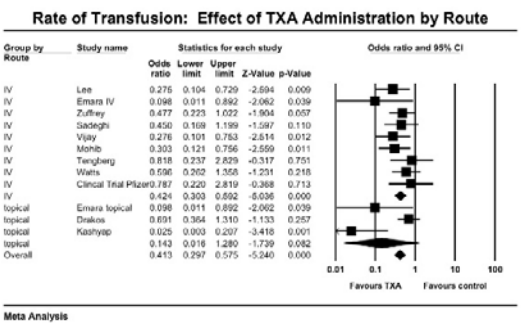
Purpose: Tranexamic acid (TXA) is an antifibrinolytic that stabilizes thrombus and decreases blood loss in the trauma setting or during surgery. The preliminary studies of TXA use in patients undergoing fracture surgery are promising. The purpose of this study was to systematically review the use of TXA in orthopaedic trauma surgery and quantify the efficacy of TXA in reducing the risk of receiving a blood transfusion and perioperative blood loss in orthopaedic trauma patients.

Methods: A systematic literature search was performed using MEDLINE, Embase, ClinicalTrials.gov, and conference proceeding abstracts from 2014-2016. The primary outcome measure was the risk of receiving a blood transfusion in the TXA group versus control. A meta-analysis was performed to construct a combined odds ratio (OR) of receiving a blood transfusion, mean difference (MD) of blood loss, and OR of thromboembolic events.

Results: 12 studies were included in the quantitative analysis (1333 patients). The risk of blood transfusion was significantly less in patients who were administered TXA compared to controls (OR 0.407; 95% confidence interval [CI] 0.278-0.594, I^2 = 34, Q = 17, P <0.001) (Fig. 1). There was no significant difference in the reduction of risk of blood transfusion between the studies of intravenous versus topical TXA. (Q-value = 0.067, P = 0.795) (Fig. 2).

Conclusion: This meta-analysis indicates that TXA has the potential to reduce both the risk of blood transfusions and blood loss in orthopaedic trauma patients. In this study, no significant effect on the rate of thromboembolic events was identified.





See pages 401 - 442 for financial disclosure information.

Δ Longitudinal Radiation Exposure in Orthopaedic Surgeons and Residents

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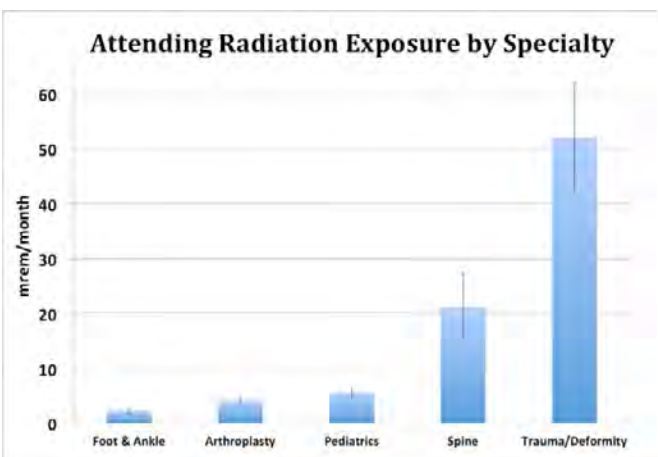
Purpose: The purpose of this study was to quantify the radiation exposure of orthopaedic surgeons and residents over a 12-month time period. We hypothesized that surgeons who subspecialize in spine or trauma would incur higher radiation exposure compared to those in other subspecialties.

Methods: Monthly radiation exposure was measured over the course of 12 months for 24 orthopaedic residents and 16 orthopaedic attendings. After each cycle the residents documented their case volume involving fluoroscopy, as well as their compliance with dosimeter wear, using a survey that was distributed after each rotation cycle. Radiation exposure was compared by subspecialty and level of training.

Results: The mean monthly radiation exposure among residents (12.4 mrem/month; range, 0-243 mrem/month) and attending surgeons (22.9 mrem/month; range, 0-355 mrem/month) were below the recommended threshold of 5000 mrem/year or 416 mrem/month. Senior residents rotating on trauma were exposed to the highest monthly radiation (78.7 mrem/month; range, 15.3-243.3 mrem/month) compared to all other specialty rotations (P <0.001) (Table 1). Similarly, attending surgeons who specialize in trauma or deformity surgery received the highest radiation exposure of their peers, and averaged 52.7 mrem/month (range, 0-355 mrem/month) (Fig. 1).

Service	Overall Mean (mrem/month)	Junior Resident Mean (mrem/month)	Senior Resident Mean (mrem/month)	p-value
Arthroplasty	0.2	0.3	0.2	0.79
Hand	0.6	0.6	0.6	0.81
Foot & Ankle	0.6	0.7	0.4	0.76
Sports	0.7	0.8	0.5	0.80
Oncology	2.4	0.32	5.0	0.11
Pediatrics	3.9	5.2	0.5	0.26
Spine	6.7	0.9	15.4	0.29
Trauma/Deformity	26.9	15.6	78.7	<0.001



Conclusion: Our study suggests that orthopaedic surgeons, both in training and in practice, are experiencing radiation doses below the occupational thresholds. The results of this study further identify the groups within orthopaedic surgery that receive relatively higher radiation exposure, namely trauma and deformity surgeons.

Δ OTA Grant

Traumatic Orthopaedic Injuries in Competitive Road Cycling

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Purpose: There is a scarcity of data on the traumatic injury rates of competitive cyclists. This study sought to document injury rates in competitive road cyclists. It was hypothesized that gender, race category level, and years of experience would correlate with risk of traumatic crashes.

Methods: A survey-based cohort study of competitive cyclists was conducted. Competitive road cyclists were enrolled and answered questions with regard to the prior year. Student t test was utilized to determine significance of safety perception, crash rates in training and racing, as well as gender, years of experience, and competitive level.

Results: The cohort (351 competitive cyclists, including 46 professionals) averaged 1.4 hours/day of riding, 8000 miles/year, and 30 race days/year. On a visual analog scale (VAS) of safety (0 being very safe, 100 being very dangerous), cyclists perceive training to be significantly safer than racing (training safety mean VAS = 35.5, racing safety mean VAS = 59.5; P <0.01). There was no significant difference in reported number of crashes in training (mean 0.94 crashes/year) and racing (mean 0.96 crashes/year; P = 0.77). The most common perceived causes of crashes in training were motor vehicles (77%) and road conditions (54%). The most common perceived causes of crashes in races were other riders taking risks (95%), race-course design (53%), and personal risk taking (48%). At least 1 crash was reported over the past year in 70% of participants. A total of 75 fractures were reported, with upper extremity the most prevalent. The most common orthopaedic injury was shoulder separation (n = 18, 5.1%), and the most common fracture was a clavicle fracture (n = 16, 4.5%). There was no difference in crash number by gender (P = 0.99), or when comparing people with <5 years of racing (n = 147) to those with >5 years of racing (n = 198; P = 0.26). There was a significantly higher total crash number in professionals (n = 46, mean = 2.69/year) compared to other competitive levels (n = 305, mean = 1.78/year; P = 0.01). Despite this, the crashes per mile ridden were similar across competitive level (professional mean 2.4 crashes/10,000 miles, non-professional mean 3.5 crashes/10,000miles; P = 0.24).

Conclusion: Cycling is a dangerous sport, with a high rate of fracture and orthopaedic injuries. The shoulder girdle is the most common site of injury. The crash volume is equivalent between racing and training. Increased years of experience and gender did not correlate with crash rate. Professional cyclists had significantly more crashes than other competitive cycling levels, but crashes per mile were consistent across race level.

See pages 401 - 442 for financial disclosure information.

Can You Believe Your Patients If They Say They Have Quit Smoking?

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Purpose: Smoking is associated with increased complications in fracture care including poor wound healing, nonunion, and infection. Patients undergoing elective nonunion surgery are often encouraged to quit secondary to increased complication risk. Some surgeons will delay surgery until a patient has quit smoking, typically relying on a patient's self-reported smoking status to make treatment decisions. However, it is unknown how reliable self-reported smoking status is in the orthopaedic trauma population. Exhaled carbon monoxide (CO) is a useful tool to assess recent smoking. The purpose of this study is to determine how reliable self-reported smoking status is in the orthopaedic trauma population. We hypothesize that self-reported smoking status is accurate.

Methods: As part of a prospective investigation we surveyed patients with a history of smoking defined as having smoked some days or every day within the last 6 months. As part of the survey patients were queried "Have you used tobacco in the last 7 days?" Following survey administration, patients underwent an exhaled CO evaluation by a research coordinator using a CO monitor. Treating providers were unaware of the exhaled CO monitor results, and participants were not incentivized to quit smoking as part of the investigation. A value of 10 ppm was selected as a cut-off for not smoking.

Results: 389 total surveys were administered. 25% of smokers (96 of 389) stated they had not smoked within 7 days, and had a negative exhaled CO reading. 71% (276 of 389) stated that they were still smoking. 4% (17 of 389) stated they had not smoked within 7 days and had a positive exhaled CO reading. Of the 113 smokers who reported not having smoked within 7 days, 85% (95% confidence interval [CI] .770-.905), 96 of 113 had confirmed negative exhaled CO readings.

Conclusion: Self-reported smoking status is a reasonably reliable indicator in most orthopaedic trauma patients. However, in our study, 15% (95% CI .095-.230) of patients falsely reported smoking status, despite no obvious incentive to falsely report smoking status, and knowledge that they were about to have CO testing to determine if they were smoking. Clinicians should be aware that the rate of incorrect reporting may be higher in a clinical situation where the patient had an incentive to falsely report smoking status. Exhaled CO can be a useful point of care screening tool to immediately confirm nonsmoking status in orthopaedic trauma patients and may be important if clinicians want to be certain that the patient has not smoked.

Investigating the "Weekend Effect" in a Serial Prospective Cohort of 29,465 Trauma Patients

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Purpose: There is increasing evidence supporting an association between hospital admission during the weekend and a higher risk of death compared with weekday admission. Our primary aim was to explore the association between weekend admission with trauma and the 30-day mortality, and to examine which patient and care-related factors influence this association. The secondary aim was to investigate if early consultant/attending clinician input after admission influenced the risk of 30-day mortality, independent of day of admission.

Methods: We performed an outcomes study of all trauma admissions to our Level I trauma center between June 2001 and December 2013 using data collected prospectively. Univariate and multivariate Cox proportional hazards models were used to compare the risk of 30-day mortality for weekend (Friday 18:00 to Monday 7:59) versus weekday admission (Monday 8:00 to Friday 17:59) and the association reported as hazard ratios (HRs). The association between early consultant/attending clinician input irrespective of day of admission and 30-day mortality was determined using multivariate models.

Results: For trauma admissions overall, there was no significant association between weekend compared to weekday admission and risk of 30-day mortality (HR 1.04, 95% confidence interval [CI] 0.96 to 1.12). Subgroup analysis demonstrated similar findings for polytrauma admissions (HR 1.07, 95% CI 0.87 to 1.31) and orthopaedic trauma admissions (HR 0.97, 95% CI 0.89 to 1.07). For hip fracture admissions, there was a significantly higher risk of 30-day mortality for patients admitted over the weekend (HR 1.19, 95% CI 1.04 to 1.36). For all cohorts, independent of weekend admission, there was a significant association between early consultant/attending clinician input and decreased risk of 30-day mortality. The corresponding HRs were: 0.799 (95% CI 0.640 to 0.998; P = 0.048) for polytrauma admissions, 0.822 (95% CI 0.720 to 0.938; P = 0.004) for orthopaedic trauma admissions, and 0.230 (95% CI 0.150 to 0.353; P <0.0001) for hip fracture admissions.

Conclusion: With the exception of hip fracture patients there was no increased risk of 30-day mortality for trauma patients admitted at the weekend, suggesting the association is condition-specific. With respect to hip fractures, there is a need to minimize the time between admission and surgery. Early consultant input independently reduces mortality risk and is a key marker of care for trauma patients.

See pages 401 - 442 for financial disclosure information.

A Predictive Score for Determining Risk of Surgical Site Infection After Orthopaedic Trauma Surgery

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Purpose: The ability to reliably predict infection risk for fracture surgery could alter management strategies, present opportunity for more effective preventive measures, and stimulate further research. We hypothesized that factors predictive of postoperative infection following fracture fixation could be determined and used to create a clinically useful score that would predict the risk of infection at the time of initial treatment.

Methods: A retrospective review at a single Level I trauma center yielded 308 deep surgical site infections per Centers for Disease Control and Prevention (CDC) guidelines between 2006 and 2015. A control group of 594 fracture fixation surgeries was created by random sampling and application of exclusion/inclusion criteria to 53,760 orthopaedic trauma surgeries. We collected data on 20 factors previously theorized to be associated with postoperative infection. Bivariate and multiple logistic regression analyses were used to build a prediction model with predictors chosen through a forward selection process. We used 10-fold cross-validation 10 times to validate the model, which was then used to create a composite score reflecting the risk of postoperative infection.

Results: The final postoperative infection prediction model consisted of 7 independent predictors including (1) male, (2) diabetes/end-stage renal disease, (3) HIV (human immunodeficiency virus)/hepatitis C, (4) fracture region, (5) open fracture, (6) ISS (<15, ≥15, unknown), and (7) methicillin-resistant *Staphylococcus aureus* (MRSA) nasal swab testing (not tested, negative, positive). Derived from the final model, the composite score ranges from 0 (lowest risk) to 22 (greatest risk). In our dataset, scores ranged from 0 to 17 with the corresponding scores for 25th, 50th, and 75th percentiles being 4, 6, and 8, respectfully. The risk strata were well correlated with the observed proportion of postoperative infection, and when adjusted for oversampling, resulted in a percent risk of infection of 2% for ≤4 points, 5% for 5-6 points, 11% for 7-8 points, 24% for 9-10 points, and 65% for ≥11 points.

Conclusion: The proposed acute postoperative infection prediction model appears to be able to determine which patients have fractures at higher risk of infection and can even provide an estimate of the percent risk of infection prior to fixation. Previous authors have attempted to create risk models for select types of fractures but this larger more encompassing work accounts for all fracture types and is based on a larger sample size.

Troubleshooting Barriers to Clinical Follow-up:
A Post-Discharge Phone Call Intervention

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Purpose: Many trauma patients do not attend scheduled outpatient appointments. Non-adherance to recommendations is associated with complications and poor outcomes, dissatisfaction, and higher costs. We initiated an intervention, consisting of a telephone call to trauma patients within 3-5 days of discharge, to answer questions and to facilitate clinic appointments. We hypothesized this would promote better attendance and greater patient and provider satisfaction.

Methods: We included 159 adult patients over 8 consecutive weeks with hospital stay >3 days. A control group of 365 similar patients discharged over the same period of time during the preceding year did not receive the intervention. Demographic and injury data and subsequent disposition were evaluated.

Results: The study group had 119 men (75%) and mean age 39.6 years (range, 18-69). Mechanisms included motor vehicle collision (26%), fall (21%), motorcycle crash (19%), and gunshot (16%). 18% were discharged home, and 57% lived within 20 miles. Our control group was evenly matched for age, gender, mechanism, spectrum of injury, and social history. One-third of intervention patients were contacted directly by phone, while 28% received a voice mail due to no person answering, and 38% could not be reached. 80% of intervention patients with appointments attended the visit versus 55% of control patients ($P < 0.0001$). Attendance at clinic visits was not related to age, gender, mechanism of injury, employment status, or hospital distance. Patients in a skilled facility were more likely to follow up (88% vs 77%, $P < 0.0001$). 49% had a positive toxicology screen on presentation. Patients with a negative screen were more likely to follow up (84% vs 75%, NS).

Conclusion: A simple telephone intervention improved follow-up rates. Hospital distance did not impact subsequent care, although patients discharged home were less likely to return. Risk factors to poor adherence require further exploration and could identify patient profiles that benefit from more support. In addition, this study has implications for appropriate system utilization, reduction of recidivism, and better outcomes, which can be found with additional programs and services for trauma patients, such as a discharge phone call, phone coaching, or other recovery programs.

See pages 401 - 442 for financial disclosure information.

Will Trauma Patients Use an Online Community to Help Cope with Traumatic Injury?

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Purpose: 60% of patients undergoing elective procedures use the Internet for information. We previously demonstrated that providing trauma patients with a custom website results in low utilization. This may be related to the content provided. Trauma patients may prefer to use the web to connect with others or learn coping skills. The purpose of this study is to characterize the usage patterns of a website designed as a community and to determine effectiveness of referral via a multicentered trial that incorporated the website into its intervention.

Methods: Our website was built in 2008 to act as a community for patients and families. The website serves as a portal to peer visitation, support groups, online forums and information on injury/recovery. Registration is free and anonymous. 49 active centers currently participate, increasing from 2008. In 2013, 6 Level I trauma centers began enrolling patients in a prospective trial to evaluate a psychosocial intervention including the web site. Traffic logs were analyzed from 2008-2015, recording trends in page views, sessions, users, and geography. Usage, defined as number of sessions (visits) and users, was compared to the number of participant centers and enrollment volume.

Results: Average views per month in 2008 were 533 and 3518 in 2015. The most frequently accessed areas were about survivor stories/peer support groups (27%), injury (24%), forums (9%), and trauma centers (6%). 20% of users were return visitors, accessing survivor stories/peer support (22%), forums (12%), trauma centers (12%), and injury (10%). The number of trauma centers correlated strongly with users, sessions, and page views (R^2 = .75, .75, and .65, $P < 0.0001$). A weak correlation was found between number of trial enrollees and monthly users and sessions, but was not significant (R^2 = .28 and .30 respectively, $P > 0.05$). Enrollment by center strongly correlated with usage from the respective site's geographical area (R^2 = .67, P = 0.02).

Conclusion: Use of our web community has increased 7 times. The use of the website and geographic distribution were both found to strongly correlate with sites emphasizing the program as part of a multicentered trial. This suggests that demand exists for an online community providing both support and information, and that referral to this service can effectively bolster participation. Future research should focus on identifying strategies for encouraging use of survivor-centric online communities and evaluating effectiveness to improve trauma outcomes.

Wound Surface Area as a Risk Factor for Flap Complications Among Patients with Open Fractures

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Purpose: Soft-tissue complications often dictate the success of limb salvage and the overall outcome of open fractures. Based on prior work at our institution, we hypothesize that wounds greater than 200 cm^2 are associated with a greater likelihood of both flap-related reoperation and wound complications among open fracture patients requiring soft-tissue reconstruction with a rotational flap or free tissue transfer.

Methods: To explore the association between wound size and the success of flap coverage, we conducted a secondary analysis on patients from the FLOW (Fluid Lavage in Open Wounds) trial. All patients that required a rotational or free tissue flap for their open fracture were included in the analysis. Our primary outcome was flap-related reoperation within 12 months of injury, and the indications were restricted to surgeries for deep infection, wound dehiscence, or necrosis. Our secondary outcome was wound complication, which included events treated operatively or nonoperatively (wound dehiscence, death of flap, necrosis, failure to close, expansion of wound, failed granulation, and infection). The primary predictor variable of interest was wound size, reported in cm^2. Multivariable logistic regression was used to assess the association between wound size and the outcomes, adjusting for relevant covariates.

Results: Of 112 patients included in the analysis, the mean age was 44.2 years (SD: 17.4) and the majority were male (78.6%). The median wound size was 29 cm^2 (interquartile range [IQR]: 9.25-120 cm^2), with 22 patients (19.6%) of the sample having a wound size >200 cm^2. 50.0% of the sample had free flaps, 48.2% had rotational flaps, and 1.4% were unrecorded. 17.0% of the patients required a flap-related reoperation. A wound size >200 cm^2 was not associated with reoperation in an unadjusted model (P = 0.64) or when adjusting for Gustilo type (P = 0.69). The sample had an overall wound complication rate of 47.3%. Patients with a wound size >200 cm^2 were 3 times more likely to experience wound complications (odds ratio: 3.57, 95% confidence interval 1.22-10.42, P = 0.02) when adjusting for diabetes, wound contamination, and wound closure in the operating room.

Conclusion: The findings of this study demonstrate that wound surface area is an integral determinant for wound complication following soft-tissue flap treatment, but found no association between wound surface area and flap-related reoperation rates.

See pages 401 - 442 for financial disclosure information.

Variations in the Organisms Causing Deep Surgical Site Infections in Fracture Patients at a Level I Trauma Center (2006-2015)

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Purpose: The purpose of this study was to quantify the current bacteriology of deep surgical site infections (SSIs) following fracture surgery at one institution and compare those data with historic controls at the same institution to determine if there is variation in the species present in infections identified over the past decade.

Methods: A retrospective review was conducted at a Level I trauma center to identify all deep SSIs (n = 243) occurring within 1 year of an index fracture fixation between January 2011 and December 2015. Bacteria were categorized as *Staphylococcus aureus* (S. aureus), coagulase-negative *Staphylococcus* (CoNS), *Streptococcus*, *Enterococcus*, gram-negative rods (GNR), gram-positive rods (GPR), anaerobes, or negative cultures. The proportion of each bacterial types was determined and compared to previously published data from the same trauma center (n = 211, December 2006 to December 2010) to assess variation in the proportions.

Results: The most common type of bacteria in the cohort was GNR (n = 109, 44.9%), followed by *S. aureus* (n = 95, 39.1%), and CoNS (n = 62, 25.5%). The proportion of CoNS species in infected patients was significantly higher ($P < 0.05$) in each study year (2011-2015) when compared to the historical controls. Similarly, the proportion of GNR species in infected patients was higher in each study year compared to the previously reported data. The difference was statistically significant ($P < 0.05$) in 2012 and 2014 and close to significant ($P < 0.08$) in the remaining years. The proportion of *S. aureus* species among infected patients was significantly less than the historic controls in 2011, 2013, and 2014 ($P < 0.05$). This reduction is specifically driven by a decrease in the proportion of methicillin-resistant *S. aureus* (MRSA) in the overall sample, with a signification reduction in 2013-2015 compared to historic controls ($P < 0.05$).

Conclusion: The bacteriology of deep SSIs of fractures has changed substantially over the past decade at our center, specifically the proportions of GNR and CoNS have increased and the rate of MRSA has decreased (all $P < 0.05$). The etiology of this change is unknown. It is possible that the use of certain perioperative antibacterial measures, such as the increase in the use of topical vancomycin powder in wounds or the switch to chlorhexidine-based skin preparation solutions, may be selecting for different bacteria. Or perhaps the decrease in MRSA rates may be reflective of the overall national decline in the rates of invasive health-care-related MRSA infections. Regardless of the etiology, clinicians should be aware that the bacteriology of SSIs at their institution may be changing relatively rapidly over time.

Δ Core Muscle Heterogeneity and Sarcopenia: A Marker for Frailty and Increased Complications in Orthopaedic Trauma Patients

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Purpose: Frailty indices are promising composite measures reflecting frailty, an age-related decrease in physiologic reserve, that can be used for patient risk stratification and interdisciplinary intervention. Sarcopenia, a radiographic measure of diminished core muscle mass, is a proxy for the Modified Frailty Index (MFI). The purpose of this study was to examine sarcopenia in orthopaedic trauma patients, to define an appropriate assessment tool in the setting of traumatic injury, and to evaluate the association with frailty scores and complications.

Methods: The institutional trauma database was queried for lower extremity fracture diagnosis codes from 2012 to 2015. The MFI was calculated for each patient identified. Frailty was defined by an MFI of 0.27 and greater. The total psoas cross-sectional area (TPA, cm^2), the mean Hounsfield Units (HU), the standard deviation of HU, and the Goutallier Classification were measured from CT scans of the abdomen and pelvis obtained at the time of injury. Several measures—TPA, mean HU, TPA × HU, TPA × body mass index (BMI), and TPA × HU × BMI—were used to radiographically classify patients. The lowest quartile for each sex for each measure was designated sarcopenic. Complications were compared between the frail and robust patients and between the sarcopenic and non-sarcopenic patients.

Results: 103 patients were identified as robust and 20 patients were frail. Frail patients experienced increased complications compared to robust patients ($P = 0.03$). Age was not predictive of postoperative complications ($P = 0.27$). Of the radiographic measures analyzed, only myosteatosis, as measured by mean HU, was predictive of increased complications in the sarcopenic group ($P \leq 0.01$).

Conclusion: Frailty is a predictor of postoperative complications in orthopaedic trauma patients. Psoas cross-sectional area did not predict frailty or complications; however, myosteatosis, as determined by a lower mean attenuation value of the psoas muscle on CT, was predictive of a higher rate of post-surgical complications in comparison to patients with higher attenuation values.

Δ OTA Grant

See pages 401 - 442 for financial disclosure information.

Publication Rates for Podium Presentations from the OTA Annual Meetings: 2008-2012

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Purpose: Orthopaedic meetings are used to disseminate current research. Presented abstracts are intended go on to journal publication. Publication rates for the OTA from 1990-1994 were 64% and from 1994-1998 were 67%. This study's purpose is to determine the journal publication rates of podium presentations from the OTA meetings between 2008 and 2012.

Methods: Podium abstracts from the 2008-2012 OTA annual meetings were compiled from OTA Electronic Archives. PubMed was queried for subsequent journal publication using title keyword search and author name. Publication rates and time to publication were calculated. Study design, journals of publication, and impact factors (IFs) were noted.

Results: From 2008-2012, overall journal publication rate for podium presentations was 73.4% (Table 1). 81% of abstracts were from US institutes, followed by Canada (8.8%) and Europe (8.4%). Top journals for publication were *Journal of Orthopaedic Trauma* (45.5%), The *Journal of Bone & Joint Surgery* (15.3%), and *Journal of Trauma* (4.6%). The most common topics are outlined in Table 2. There was no significant difference in time to publication (P = 0.56) or IF (P = 0.24) between years. Study design and associated publication rates are noted in Table 3.

Table 1: Podium Abstract Publication Rate

	2008	2009	2010	2011	2012	Total
Abstract podium presentations	72	64	61	67	93	357
Journal publication rate	72.2% (52)	79.7% (51)	72.1% (44)	76.1% (51)	66.7% (62)	72.8% (260)
Mean time to publication (years)	2.02 (1.13 to 8.02)	2 (3.36 to 5.56)	2.23 (0.10 to 5.98)	1.79 (0.28 to 4.72)	1.8 (1.93 to 4.17)	1.95 (3.36 to 8.02)
Published within 3 years	78.9%	76.5%	75.0%	88.2%	85.5%	81.2%
2012 impact factor	2.33 ± 0.94	1.99 ± 0.91	2.11 ± 1.11	2.01 ± 0.80	1.98 ± 0.75	2.06 ± 0.90

Table 2: Abstract Sessions and Publication Rates

	Published	Unpublished	Percent Published
Basic Science	25	14	64.1%
Foot & Ankle	28	10	73.7%
General Interest	5	5	50.0%
Geriatric	21	5	80.8%
Hip/Femur	23	15	60.5%
Injury Prevention	10	0	100%
Knee/Tibia	34	9	79.1%
Pediatrics	16	7	69.6%
Pelvis & Acetabulum	24	14	63.2%
Polytrauma	25	4	86.2%
Reconstruction	5	2	71.4%
Spine	8	5	61.5%
Upper Extremity	36	7	83.7%

Table 3: Study Design and Publication Rate

	Published	Unpublished	Percent Published
Multi-center RCT	8	3	72.7%
Single-center RCT	27	2	93.1%
Prospective	36	21	63.2%
Retrospective	152	52	74.5%
Biomechanical/Basic Science	26	8	76.5%
Other	11	11	50.0%

Conclusion: Despite an increase in abstract submissions and the number of podium presentations, journal publication rates remain high. The publication rate for OTA podium presentations indicates a high level of scrutiny for OTA abstract acceptance and quality.

Time-Driven Activity-Based Costing in Trauma

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Purpose: Data on the cost of care in orthopaedics is critical to control health-care expenditures and improve value. Accurate cost data are hard to obtain and variability exists in accounting methods. Studies in arthroplasty have shown accuracy in Time-Driven Activity-Based Costing (TDABC). The purpose of this study was to use surgical treatment of ankle fractures to compare TDABC and our institution's traditional accounting (TA) method.

Methods: Level I trauma center ankle fractures treated between 2012 and 2016 were identified through a registry. Inclusion criteria were ≥18 years of age and same day ankle fracture operation. Exclusion criteria were pilon fractures, vascular injuries, soft-tissue coverage, and external fixation. Process maps were developed for each phase of care. The TA method at our institution uses all hospital costs and allocates them to surgeries using a relative value method.

Results: A total of 35 patients met inclusion/exclusion criteria, 18 male and 17 female. Age at time of surgery was 47 ± 15 years. Time from injury to surgery was 10 ± 4 days. Operative time was 86 ± 30 minutes. Average cost was significantly lower for the TDABC method ($2792 ± 734) than the TA method ($5782 ± 1348) ($P < 0.001$). There was no difference between methods for implant cost. TA produced a significantly greater cost ($P < 0.01$) in every other category.

Conclusion: As orthopaedics transitions to alternative payment models accurate costing will become critical to maintaining a successful practice. The TDABC method appears be more accurate to capture and manage cost of resources utilized.

See pages 401 - 442 for financial disclosure information.

Developing Metrics for Simulated Surgical Training by Proficiency-Based Progression

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Purpose: Traditional assessment of surgical teaching based on years of training is not reflective of individual learner proficiency. With increased demand to quantify learning and skill level (proficiency), the interest for standardized measures has grown. Likert-type assessment tools are prone to subjectivity. We propose to use a method that is based on a binomial (yes/no) rating of simulated surgical tasks based on Proficiency-Based Progression (PBP). The poster describes the metric development and validation.

Methods: In PBP, the development of objective metrics of surgical task performance involves: (1) procedure identification, (2) tasks analysis, (3) operational metrics definition and verification, (4) metric validation by a Delphi panel (face validity), and (5) measurement of construct validity, inter-rater reliability (IRR), and responsiveness of task metrics. We added (6) measurement of baseline demographic, clinical experience, and visuospatial ability. We developed metrics for the performance of surgical tasks at 4 skill stations and 1 clinical simulation laboratory (fibula fracture fixation in an ankle fracture model) used for training of orthopaedic surgery residents attending an AO Basic Principles Course. The investigator team completed steps 1, 2, and 3. A Delphi panel of experienced surgeon-educators approved the measures, (step 4). Steps 5 and 6 were completed by asking faculty members (Experienced [E], n = 20), and postgraduate year (PGY)1-2 participants (Novice [N], n = 23). Tasks were recorded on video and scored by 2 independent raters. Validity, reliability, and responsiveness were measured and group results were compared by IRR, and chi-squared and analysis of variance, respectively.

Results: No significant difference in visuospatial testing was identified between E and N participants. Significant differences were observed between E and N in their ability to complete tasks within the set measured parameter tolerances or absolute measures: drill aiming and plunging tasks: E = 73%, N = 58% ($P < 0.05$); screw torque task: E = 93%, N = 67% ($P < 0.05$); hardware removal time ($P = 0.001$); hardware removal errors ($P = 0.004$); ankle fixation time ($P < 0.05$); and ankle fixation errors ($P < 0.05$). IRR for occurrence of an error for hardware removal and ankle fixation were 0.7 and 0.75.

Conclusion: The development of discrete binomial metrics for assessment and training of tasks in a PBP model was successfully extended to surgical fracture care training, showing good face and construct validity and good ability to discriminate between novice and expert performers of the tasks.

Social Relationships Are Strained Following Common Orthopaedic Trauma

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Purpose: Social strain has been demonstrated to act as a trigger of psychological distress and decreased quality of life. The purpose of this study was to investigate the prevalence and longitudinal improvement of patient-reported problems with family and friends following 4 common orthopaedic fractures.

Methods: The functional status of patients with fractures of the tibial plateau, ankle, proximal humerus, and distal radius were prospectively followed. Patients reported if they experienced social strain (problems with their family and friends) at baseline and at 3, 6, and 12 months post treatment. The functional outcomes of patients were obtained using the Short Musculoskeletal Function Assessment (SMFA) for tibial plateau and ankle fractures. The Disabilities of the Arm, Shoulder and Hand (DASH) survey was used to assess functional outcomes in proximal humerus and distal radius fractures. Student t tests were used for continuous variables. Chi-squared analysis was used to assess differences between categorical variables. Spearman's correlation was used between functional outcomes and social strain.

Results: 1314 patients were included in this study. Overall, the prevalence of social strain was highest at the 3-month time point and subsequently improved. Social strain was demonstrated in 20.7% of patients at 3-month follow-up and in 7.6% of patients at 12-month follow-up. Strong correlations exist between social strain and functional outcomes ($P < 0.001$). Patients who reported social strain were of older age, at 6-month ($P = 0.011$) and 12-month follow-up ($P < 0.001$). Non-Caucasian ethnicity was associated with social strain at 3-month follow-up ($P = 0.025$).

Conclusion: Strong social circles have been well documented as contributing to increased longevity and quality of life. This study demonstrated that social strain is prevalent following common orthopaedic trauma, yet it decreases as time goes on. Problems with family and friends following orthopaedic trauma were more common in older patients at all time points. In addition, female patients experienced more social strain at short-term follow-up. Patients who experienced problems with family and friends had worse functional outcomes at short and long-term follow-up. This study should allow orthopaedic trauma surgeons to counsel patients regarding expectations of their relationships after common fractures.

See pages 401 - 442 for financial disclosure information.

Quantified Surgical Training by Simulation for Ankle Fracture Care: Using Proficiency-Based Progression

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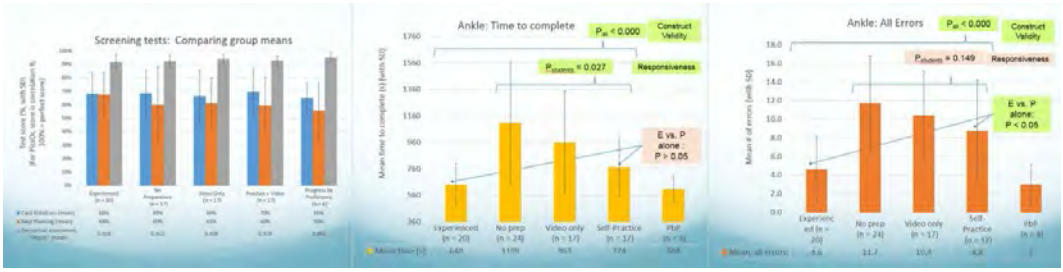
Purpose: Traditional assessment of surgical teaching occurs without validated metrics. The Proficiency-Based Progression training model (PBP) suggests a process where discrete error-recognizing (binomial) items are used to develop a score sheet. Learners are then trained to proficiency (using the items) before their performance of a task is evaluated. We compared the performance of residents who were randomly assigned 1 of 3 different types of learning approaches: video training alone (V), video plus practice on their own (P), and video plus practice to proficiency by a coach (PBP) prior to evaluation of tasks.

Methods: Junior residents attending an AO Basic Course randomly received 1 of 3 forms of teaching: V, P, or PBP. Following completion of their "teaching" they were asked to complete surgical tasks at 4 Sawbones skills stations and 1 fibular fixation station. Performances were recorded by digital video and scored live or at a later time by video by 2 independent assessors using the score sheet (IRR range = 0.7-0.75).

Results: 38 novice (N) residents and 20 experienced (E) faculty members participated. For ankle fixation station: there was a statistically significant difference in procedure time to completion between the E and N groups. The N group additionally showed a progressive decrease in time as practice intensified with PBP results nearly approximating the E groups. There were similar findings for error counts (Fig. 1).

Conclusion: This work demonstrates improved performance as the level of resident engagement intensifies, with the best results appearing in the PBP group. The present findings support moving to that model for teaching ankle fracture fixation.



Improvement in Functional Outcomes After Symptomatic Implant Removal: Upper Versus Lower Extremity

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Purpose: Implant removal (IR) is one of the most common orthopaedic procedures, but outcome studies for IR are scarce. There are no guidelines regarding hardware location, timing of removal, or expected functional improvement. The purpose of this study is to evaluate the effect of symptomatic upper and lower extremity IR using the Short Musculoskeletal Function Assessment (SMFA) dysfunction index as the primary outcome.

Methods: From 2013-2016, a prospectively collected outcomes registry of IR patients was retrospectively reviewed. Inclusion criteria were skeletal maturity, symptomatic implants, and completion of the SMFA questionnaire prior to and after IR. Exclusion criteria were nonunion, infection, or complex regional pain syndrome following initial procedure. The primary outcome was change in SMFA score from baseline. A multivariate regression analysis evaluated the effects of age, sex, body mass index (BMI), smoking status, diabetes, history of depression and anxiety, Workers' Compensation status, and time from primary surgery on outcomes.

Results: A total of 160 patients, 41 upper extremity (UE) and 119 lower extremity (LE), IRs were included. The UE cohort had a mean age of 50.3 years (range, 17 to 79) with 21 females and 20 males. The LE cohort had a mean age of 48.9 years (range, 17 to 83) with 80 females and 19 males. Follow-up SMFA questionnaires were completed at 5.9 (range, 5.0 to 8.5) and 5.8 (range, 5.0 to 11.5) months for UE and LE, respectively. The index improved significantly from baseline to follow-up for LE ($P < 0.001$) with a trend to significance for UE ($P = 0.059$). This did not significantly differ between the 2 ($P = 0.47$), although the LE cohort had a significantly worse baseline ($P = 0.02$). Multivariate regression found a significantly worse functional outcome in the LE group with regard to a history of depression and anxiety ($P = 0.039$) and a trend to significance with BMI ($P = 0.076$). No factors were found to be significantly related to outcome in the UE group.

Conclusion: Implant removal in both the UE and LE show improvement in function, with removal from the LE reaching significance. The significantly earlier IR time for UE may be related to primarily prominent implants with minimal concern regarding functional loading, while the significantly worse baseline LE SMFA may indicate greater functional impairment related to weight-bearing activities.

See pages 401 - 442 for financial disclosure information.

True Cost Savings of Fracture Surgery Performed by Trauma-Trained Orthopaedic Surgeons Versus Non-Trauma Specialists at a Level I Trauma Center

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Purpose: Central to reducing waste and inefficiencies in healthcare spending is accurately measuring costs. Previous attempts at measuring costs have focused on patient charges, but are highly inaccurate due to hyperinflation to allow cross-subsidization of services. Value Driven Outcomes (VDO) is a unique validated analytics framework developed at our institution in 2012 to efficiently identify costs of individual components of patient care encounters. This study compares the costs for commonly performed fracture surgeries when performed by trauma fellowship trained surgeons versus non-trauma fellowship trained surgeons.

Methods: We conducted a retrospective chart review and cost analysis on all operative, isolated distal radius, both bone forearm, hip, femoral shaft, distal femur, tibia and ankle fractures cared for at our Level 1 Trauma Center. Medical records were reviewed to determine patient age, BMI, medical comorbidities, ASA score, hospital length of stay, fracture pattern, and implants utilized. True dollar costs to the system were determined using VDO tools. Costs were analyzed using a multivariate generalized linear model (GLM).

Results: 1026 patients were identified for this study. When comparing patients between trauma and non-trauma trained groups, patients were significantly older (34.7% vs 20.1% age > 65, p<.001), sicker (38.9 % vs. 21.1% ASA > 2, p<.001), less privately insured (49.2% vs 65.4%, p<.001), and more likely to be treated in an inpatient setting (78.2% vs 31.6%, p<.001) when treated by a trauma trained surgeon. Results from the GLM with a trauma trained group interacted with fracture type showed significantly reduced total health care costs for the trauma trained group for treatment of tibial shaft fractures (22.1% cheaper, p=0.044) and hip fractures (21.7% cheaper, p=0.027). There was a near significant effect on distal femur fractures (29.7% cheaper, p=0.063). Trauma training showed non-significant savings on all fractures with the exception of distal radius fractures. Cost savings were most attributed to lower facility utilization costs, which includes OR time/cost.

Conclusion: This is the first study to use cost data to assess fracture care delivery expenses. Orthopaedic trauma fellowship training is associated with lower costs (21.7-29.7% cheaper) for the treatment of common fractures. This cost difference is most attributed to lower OR time/cost. This further demonstrates the financial value of orthopaedic trauma specialists to the healthcare system and to hospitals.

Long Term In Vitro Testing of a Wireless Pressure Sensor for Detection of Acute Compartment Syndrome

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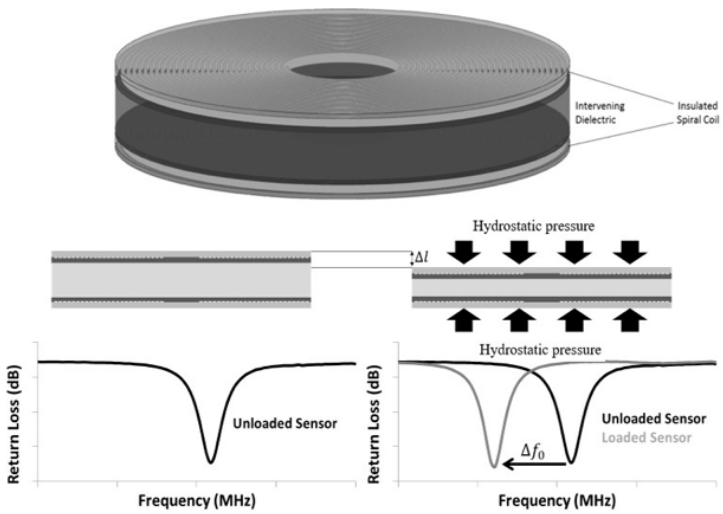
Purpose: Acute Compartment Syndrome (ACS) is a true orthopedic emergency. Continuous monitoring of intracompartmental pressures (CMICP) is effective for early and accurate diagnosis of an impending ACS. Few clinical techniques are available for CMICP due to the need for an indwelling catheter. The purpose of this study was to design, fabricate, and test a wireless pressure sensor for CMICP.

Method: Prototype sensors were fabricated by curing a layer of closed cell foam between two 1.1 cm diameter planar spiral coils. The two coils electrically couple to form a resonant circuit whose resonant behavior is dictated by coil separation. Changes in pressure deforms the closed cell foam which is transduced into a wirelessly detectable resonant shift. Six sensors were fabricated and exposed to cyclic pressure changes between 10 and 130 mmHg to evaluate the pressure-frequency relationship in saline. One sensor was selected for a week-long pressure test in saline to test clinical potential.

Results: The six sensors exhibited a mean sensitivity of 210±36 (S.E.) mmHg/MHz. During the weeklong testing the sensor exhibited a 4% drift in resonance over the first four days, however it stabilized to within 0.1% for the final three days and exhibited a sensitivity of 119.8 mmHg/MHz.

Conclusion: This work demonstrates that long term wireless pressure sensing for ACS is feasible without the need for on-board electronics. Its passive nature and simple wireless interrogation scheme gives the sensor potential to be robust, clinically relevant tool for ACS diagnosis.



See pages 401 - 442 for financial disclosure information.

Δ Hemiarthroplasty Versus Reverse Total Shoulder Arthroplasty for the Management of Proximal Humerus Fractures in the Elderly: A Retrospective Review of a Large Population Database

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Purpose: The management of proximal humerus fractures (PHFs) remains an area of substantial controversy. Complex fractures in elderly patients are often managed with hemiarthroplasty (HA). Outcome after HA is highly dependent upon healing of the tuberosities and rotator cuff function, both of which can be unreliable in this patient population. Reverse total shoulder arthroplasty (RTSA) has emerged as an attractive treatment option, as outcomes may be less reliant on tuberosity healing and intact rotator cuff function, though concern exists for higher revision rates. The purpose of this study was to compare reoperation rates between HA and RTSA for the acute management of PHFs in older adults.

Methods: Patients 50 years and older with a main diagnosis of PHF were identified from emergency departments across Ontario from 2004-2013. Those with an intervention code of HA or RTSA within 4 weeks of the index fracture were included. The primary outcome was reoperation within 2 years. A chi-square test was used to compare the unadjusted reoperation rates. Logistic regression was used to compare outcomes while adjusting for clinically important co-variables, and to identify independent risk factors for reoperation.

Results: A total of 1352 patients were identified, 1099 treated with HA and 253 with RTSA. A total of 169 (15.4%, 95% CI=13.4-17.6) patients within the HA group and 39 (15.4%, 95% CI=11.5-20.1%) patients within the RTSA group underwent repeat surgery within 2 years of the index procedure. The unadjusted rate of reoperation was not significantly different between groups (p=0.80). In addition, reoperation rates were not significantly different after adjusting for age, comorbidities, teaching hospital, diagnosed osteoporosis, rural residence, income quintile, or initial length of stay. Only age (odds ratio [OR] = 1.04, 95% CI=1.0-1.04), the presence of diagnosed osteoporosis (OR = 2.5, 95% CI=1.4-4.6), and a high level of comorbidities (OR = 2.2, 95% CI=1.1-4.2) were independently associated with reoperation rates.

Conclusion: Both HA and RTSA are used for the management of acute PHFs in the elderly across Ontario. In contrast to previous studies, HA and RTSA did not demonstrate significantly different reoperation rates in the treatment of acute PHFs in elderly patients. Our results, while limited by a lack of functional outcome data, suggest further investigation is required to define the relative roles of these 2 arthroplasty options in the management of acute PHFs.

Δ OTA Grant

Comparison of Surgical and Nonsurgical Treatments for 3 and 4-Part Proximal Humerus Fractures in Patients Over 65 Years: A Network Meta-Analysis

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Purpose: Proximal humerus fractures (PHFs) are the third most common fracture type in individuals over 65 years. Treatment strategies include nonsurgical treatment (NST), open reduction and internal fixation (ORIF), hemiarthroplasty (HA), and reverse total shoulder arthroplasty (rTSA). We used network meta-analysis (NMA) of randomized controlled trials (RCTs) to compare the adverse events, reoperation rates, and functional outcomes associated for the treatment of 3 and 4-part PHFs in elderly patients.

Methods: We searched MEDLINE, Embase, Web of Science, and Cochrane Central electronic databases for RCTs comparing 3 and 4-part PHF treatments in the elderly. Ultimately 8 papers met our inclusion criteria for NMA. We extracted information on country, sample size, age, length of follow-up, adverse event rates, additional surgery rates, Constant scores, and Disabilities of the Arm, Shoulder and Hand (DASH) scores. There was no significant heterogeneity among included studies, and the probability of publication bias was not significant per Egger's test (P = 0.21). Therefore, a fixed effect analysis was employed. The pooled standardized mean difference (SMD) was calculated and presented with 95% confidence interval (CI). Pooled risk ratio (RR) with 95% CI was used to compare adverse event and additional surgery rates.

Results: Eight RCTs were included with a total of 364 participants and an average age of 73.4 years. rTSA resulted in significantly better combined Constant/DASH score than HA at the latest available follow-up time (SMD = 0.89; 95% CI = 0.36-1.41; P <0.01). There were no significant differences between ORIF versus NST, HA versus NST, and HA versus ORIF. rTSA was associated with a lower adverse event rate than HA (RR = 0.57; 95% CI = 0.36-0.90; P = 0.02) while ORIF was associated with a higher rate than NST (RR = 1.45; 95% CI = 1.10-1.91; P <0.01). There were no significant differences between HA versus NST and HA versus ORIF. ORIF was associated with an increased rate of additional surgery compared to NST (RR = 8.13; 95% CI = 2.10-31.60; P <0.01). There were no significant differences between rTSA versus HA, HA versus NST, and HA versus ORIF.

Conclusion: This study supports the accumulating body of evidence suggesting that NST should be the preferred treatment strategy. In cases where surgical treatment is deemed necessary, rTSA should be preferred over HA as it produces better outcomes, a lower rate of adverse events, and no difference in rates of additional surgery.

See pages 401 - 442 for financial disclosure information.

Δ Factors Associated with Ulnar Neuropathy After Bicolumnar Plate Fixation of Distal Humerus Fractures

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Purpose: Ulnar nerve symptoms after surgical fixation of distal humerus fractures are common. The purpose of this study was to assess the risk factors associated with postoperative ulnar nerve symptoms in patients undergoing surgical fixation of distal humerus fractures.

Methods: The results of a previously presented randomized controlled trial were utilized. Patients were followed for 1 year, and comprehensive neurological, functional, and electrophysiological assessments were conducted. Multiple factors were examined in an "a priori" manner to assess the risk of ulnar neuropathy. The purpose was to identify risk factors associated with ulnar neuropathy, and risk factors associated with abnormal electromyographic (EMG) results.

Results: 58 patients were examined (mean age 52 years, 60% female). The rate of ulnar neuropathy was high at all times points: 95% preoperatively, 98% at 6 weeks, 86% at 3 months, and 75% at 1 year postoperatively. At 6 weeks the prevalence of ulnar neuropathy was highest in patients treated with a triceps sparing approach (89%), compared to triceps split (35%, P = 0.003) or olecranon osteotomy (25%, P = 0.003), as well as patients treated with 90-90 plating (76%) compared to 180° plating (35%, P = 0.008). Multivariable analysis demonstrated that a triceps-sparing approach increased the risk of ulnar neuropathy compared to triceps split (odds ratio [OR] 7.8, P = 0.03) and olecranon osteotomy (OR 28.6, P = 0.016), while plate position did not show an effect. At 6 weeks, 60% of patients had EMG abnormalities (44% severe, 56% minor). The presence of EMG abnormality had no effect on patients' functional outcome (Disabilities of the Arm, Shoulder and Hand [DASH] or Mayo Elbow Performance Score [MEPS]) at any time point; however, it was associated with higher rates of ulnar neuropathy at nearly all time points postoperatively. Controlling for other factors in a multivariable analysis, the only factor increasing the risk of EMG abnormality was a triceps-sparing approach compared to triceps split (OR = 8.3, P = 0.03) or olecranon osteotomy (OR = 13.9, P = 0.04).

Conclusion: The incidence of ulnar neuropathy after bicolumnar plate fixation of distal humerus fractures is high. EMG abnormalities are highly correlated with ulnar neuropathy symptoms in the short and long term; however, outcome scores (DASH and MEPS) are not sensitive enough to capture such dysfunction. The use of triceps-sparing approach, which may cause further ulnar nerve manipulation, may lead to increase in neuropathy symptoms. Patient education regarding the high prevalence of postoperative neuropathy, along with careful handling of the nerve intraoperatively, are of importance.

Δ OTA Grant

Comparison of Home-Based and Formal Physical Therapy on the Effect of Patient-Reported Outcomes in Proximal Humerus Fractures Treated Nonoperatively

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Purpose: Proximal humerus fractures are increasingly common, representing 6% of all fractures. There is significant variability in rehabilitation protocols in patients being treated nonoperatively. It is not yet known what effect formal physical therapy has on patient-reported outcomes of recovery after proximal humerus fracture. The goal of this study was to evaluate the effect of formal physical therapy against home-based physical therapy on patient-reported outcomes in proximal humerus fractures treated nonoperatively.

Methods: Potential subjects from February 2015 through July 2016 were identified using billing codes, and screened for inclusion criteria. Exclusion criteria included operatively treated fractures and patients under 18 years at the time of injury. Patient-Reported Outcomes Measurement Information System (PROMIS) data for Function, Pain, and Mood were collected at the initial visit and compared against the final follow-up encounter.

Results: The mean age of subjects at the time of injury was 62.5 ± 17.5 years (current age 62.7 ± 17.5 years) involving 160 fractures. 55fractures were treated without formal physical therapy (home-based therapy) while 105 fractures were treated with a formal physical therapy regimen. In patients who participated in a home exercise program, the mean difference in patient-reported function, pain, and mood were 3.76 (-0.29, 7.82; P = 0.0686), -6.70 (-10.66, -2.74; P = 0.0011), and -3.80 (-7.62, 0.02; P = 0.0514), respectively. For patients undergoing formal physical therapy, the mean differences in reported function, pain, and mood were 4.80 (2.05, 7.56; P = 0.007), -8.16 (-10.57, -5.75; P <0.0001), and -2.72 (-5.25, -0.19; P = 0.0353), respectively. When comparing individuals who did not undergo formal physical therapy with those who underwent formal physical therapy, there were no significant differences in patient-reported function (P = 0.5551), pain (P = 0.6237), or mood (P = 0.4655).

Conclusion: Prescription of formal physical therapy does not improve patient-reported function, pain, or mood PROMIS scores at time of discharge after sustaining a fracture of the proximal humerus.

See pages 401 - 442 for financial disclosure information.

Intra-Articular Distal Humerus Fractures: Clinical Results of Parallel Versus Orthogonal Plating

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Purpose: Dual plating osteosynthesis is the standard treatment for OTA type 13-C distal humerus fractures. However, optimal plate position is debated. The purpose of this study is to evaluate dual plate positioning in such cases by comparing outcomes between patients plated in parallel (180°) and those plated orthogonally (90°) following open reduction and internal fixation (ORIF) of intra-articular distal humerus fractures.

Methods: A retrospective review of all OTA type 13-C intra-articular distal humerus fractures treated operatively by 3 different fellowship-trained orthopaedic trauma surgeons over a 5-year period was performed. In each case, patient demographics, injury information, and surgical management were recorded. Measured intraoperative outcomes included operative time and blood loss while postoperative outcomes included range of elbow motion, time to union of the distal humerus fracture, and development of complications (nonunion, infection, symptomatic hardware, and reoperation). Mayo Elbow Performance Index (MEPI) scores were also obtained for patients utilizing the functional information recorded in their latest clinical note. Data were analyzed using independent samples t tests, chi-squared tests, and Fisher's exact tests.

Results: Of the 111 eligible fractures treated during this time period, there were a total of 60 patients who met inclusion criteria. Mean follow-up among this cohort was 13.3 months. 44 patients (73.3%) had orthogonal dual plating, and 16 (26.6%) had parallel plating. Groups did not differ with respect to any demographic information, fracture type, or duration of follow-up. All fractures eventually went on to heal. 3 patients from the orthogonal cohort had hardware failure at the medial plate. Clinically, there were no significant differences in time to union, elbow arc of motion, or patient MEPI score. Further, there were no differences in complications. However, there was a higher incidence of prominent/mildly symptomatic hardware that did not require surgical removal among patients plated orthogonally ($P = 0.04$).

Conclusion: Parallel and orthogonal plating following ORIF of distal humerus fractures with modern, contoured locking compression plates had similar outcomes in this study, although a higher rate of prominent hardware not requiring surgical removal was observed with orthogonal plating. Both techniques may be considered when deciding on dual plating technique for treating intra-articular distal humerus fractures.

Proximal Humerus Absolute Reintervention to Arthrolysis, Arthroplasty, or Hemiarthroplasty: Survivorship and Long-Term Outcomes of the PHARAOH Study

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Purpose: Proximal humerus fractures represent an important fragility fracture frequently managed by orthopaedic surgeons. Recent research has focused on the optimal treatment modalities for these injuries. Open reduction and internal fixation (ORIF) of proximal humerus fractures remains a topic of debate. This study evaluates the survivorship and functional outcomes after initial fixation of patients with proximal humerus fractures.

Methods: A single center prospective database review identified 579 patients treated surgically with proximal humeral ORIF between 1996 and 2015. Inclusion criteria were: acute proximal humerus fracture treated with ORIF, age over 14 years at the time of injury, and a minimum of 2 years follow-up. Patient demographics, patient-reported outcomes, complications, and the need for additional surgery were recorded. Study end points included: revision ORIF, conversion to arthroplasty, arthroplasty, and death. Kaplan-Meier survival analysis and Cox proportional-hazards regression were performed to assess for risk factors for failure.

Results: 337 patients met inclusion criteria. 27 patients were excluded and 238 patients had data available (77% response rate). 71 patients were deceased (30% mortality) and 3 institutionalized. Mean follow-up was 7.9 years. Average age at the time of operation was 58 years (SD 13). Fracture type by Neer classification included: 38% type 2, 28% type 3, and 34% type 4. 34 anterior fracture dislocations and 43 posterior fracture dislocations were included. Oxford Shoulder Score and QuickDASH (an abbreviated version of the Disabilities of the Arm, Shoulder and Hand [DASH]) scores were 32.2 and 16.9, respectively. 28% of patients underwent reintervention for any cause. Median survival time to reintervention was 76 months and 93 months for survival to arthroplasty. At a mean of 7 years post ORIF, 72% of patients remained reintervention-free. Renal disease was the only significant predictor of reintervention. 11% (19 patients) required conversion to arthroplasty. Overall patient-reported shoulder satisfaction was high; mean global shoulder score was 83% (SD 18.6) at 2 years post procedure.

Conclusion: Overall, our data suggest that ORIF for proximal humerus fractures does not result in early revision or arthroplasty and survival of the procedure is the norm. Additionally, failure requiring conversion to arthroplasty or revision generally occurs late (>7 years). Furthermore, we demonstrated that a subset of patients may be at higher risk of requiring additional reoperation or revision.

See pages 401 - 442 for financial disclosure information.

Δ Evaluating the Utility of the Lateral Elbow Radiograph in Central Articular Olecranon Reduction: An Anatomic and Radiographic Study

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Purpose: The surgical reduction of intra-articular olecranon fractures is judged primarily on the lateral elbow radiograph, as orthogonal articular imaging is not obtainable. Our interpretation of the olecranon articular surface on a single radiograph may be inadequate given its complex anatomy. As such, surgeons may fail to recognize olecranon articular malreduction intraoperatively, resulting in poor postoperative outcome. We sought to determine surgeon accuracy in identifying intra-articular olecranon malreductions on the lateral elbow radiograph.

Methods: Six human fresh-frozen cadaveric elbow specimens were sagitally sectioned in 5-mm increments after olecranon dissection, preservation of soft-tissue envelope, and rigid fixation of the elbow in an external fixator. Three distinct patterns of central intra-articular olecranon malreduction were created in each elbow using a ruler and a standard bone saw. Perfect lateral elbow radiographs were taken of each malreduction, and these images were randomized along with radiographs of normal cadaveric olecranons. The image series was presented to 4 blinded trauma-trained surgeons to determine if the olecranon was malreduced or anatomic. Surgeons interpreted the same image series on 2 separate occasions separated by 6 weeks. Percent correct was recorded and inter- and intra-observer reliability was calculated.

Results: Orthopaedic trauma surgeons correctly identified olecranon malreductions only 73% of the time on the lateral elbow radiograph. Inter-observer agreement was moderate for the first review of images and fair for the second review, with respective Fleiss kappa values of 0.43 and 0.28. Intra-rater reliability revealed moderate agreement with Cohen's kappa value ranging from 0.56 to 0.66.

Conclusion: Intra-articular olecranon malreductions are inconsistently recognized by trauma surgeons on the lateral elbow radiograph. The complex anatomy of the olecranon articular surface likely contributes to this discrepancy. Therefore, articular incongruity may still be present post-surgical fixation of comminuted olecranon fractures. We must further define the radiographic anatomic representation of the articular olecranon in order to improve surgical reduction and clinical outcomes.

Δ OTA Grant

Developing a Virtual Fracture Clinic for Hand and Wrist Injuries

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Purpose: The treatment of hand and wrist trauma is time-critical. With increasing patient numbers, demand for resources, devolving of emergency department care to junior staff and non-medical practitioners, as well as pressures on trauma clinics, it has become more difficult to provide high-quality trauma care for these common injuries. New methods of working are required. The use of "virtual clinics" has been trialed in other areas. We piloted the use of a virtual fracture clinic for hand and wrist trauma referrals in a major trauma center. We hypothesized that this model would offer demonstrable benefits, would be safe, and it would allow the patient to receive the right treatment from the right person at the right time.

Methods: We established a twice-weekly virtual clinic for hand and wrist fractures. Over a 20-week period every referral was scrutinized and the associated imaging was reviewed by a specialist attending hand and wrist surgeon. The patient was contacted directly by telephone or letter to communicate the outcome of this virtual clinic. We reviewed all relevant complaints, compliments, significant incidents, and adverse events over this period using the department governance structure and hospital complaints reporting and tracking system.

Results: We reviewed 291 patients in the hand and wrist virtual fracture clinic over 20 weeks. 104 patients were referred directly for hand therapy without requiring a formal fracture clinic appointment. A further 26 patients were selected for direct referral to hand therapy but declined to be referred in this way without seeing a doctor. 54 patients were discharged directly following the virtual fracture clinic with advice. 98 patients were formally reviewed in the fracture clinic. 26 of these patients went on to have surgery.

Conclusion: Hand and wrist fractures make up the bulk of the trauma load but a large proportion of these injuries do not require operative intervention. Our study shows that moving the senior decision-making point forward to the patient in a virtual environment can streamline patient pathways, reduce delays, and offer safe treatment. Our initial experience has suggested that patient education can have a profound effect on the acceptability of this model to patients. The one adverse outcome in this pilot was related to an administrative error and underlines the importance of adequate resource and support, but we feel that this is comparable with traditional models of care.

See pages 401 - 442 for financial disclosure information.

Sequential Radiographic Evaluation During Nonoperative Treatment of Distal Radius Fracture

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Purpose: Nonoperative treatment by closed reduction and immobilization is a standard of care in adequately reduced stable type distal radius fractures. The AAOS recommends weekly serial radiographs for 3 weeks to identify early loss of reduction that may alter treatment. The purpose of this study is to test the null hypothesis that there is no significant change in radiographic parameters, which determines an acceptable reduction, beyond 3 weeks in nonoperatively treated distal radius fractures.

Methods: We analyzed a prospectively gathered registry of nonoperatively treated distal radius fractures using radiographic measurements by 2 investigators including radial inclination, radial height, ulnar variance, tilt, teardrop angle, AP distance, intra-articular gap, and step-off. Acceptable reduction was defined as radial shortening <3 mm, dorsal tilt <10°, or fracture with intra-articular displacement or step-off <2 mm. We compared post-reduction radiographic parameters within 2 weeks, the third week, at cessation of immobilization, and performed interobserver reliability test.

Results: There was a statistically significant difference between radiographic measurements, which determined an acceptable reduction between radiographs performed within 2 weeks versus the third week. Radial inclination and ulnar variance were statistically different at the third week versus the time of cessation of immobilization. 77% of patients who had an acceptable reduction after 2 weeks maintained acceptable alignment at cessation of immobilization. 85% of patients who had an acceptable reduction after 3 weeks maintained an acceptable alignment at cessation of immobilization. Radial shortening >1.8 mm at the third week predicts an unacceptable radiographic outcome at cessation of immobilization (sensitivity 94.5% and specificity 90%). There is a high interobserver agreement for all measurements except intra-articular gap and intra-articular step-off. The reliability test of AP distance, teardrop angle, and tilt of post-reduction within 2 weeks was moderate.

Conclusion: Radiographic parameters that determine acceptable reduction for nonoperative treatment of distal radius fracture minimally change after 3 weeks post-reduction. Radial shortening at the third week can be used as a predictor for unacceptable radiographic outcome.

Accurate Measurement of the Sliding Distance of a Lag Screw Using 3D Reconstruction Modeling

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Purpose: Cephalomedullary nailing (lag screw system) has become a popular treatment for unstable intertrochanteric fractures. Sliding distance is usually measured using a standard AP hip radiograph. However, it is frequently taken with the limb in external rotation and/or flexion of the lower limb and that causes inaccurate measurement of the sliding distance (SD) of a lag screw. Here, we developed a new 3-dimensional (3D) reconstruction modeling method to make an accurate measurement of the SD of a lag screw, and then we evaluated the accuracy of this new method by comparing the conventional method with it.

Methods: Radiographs of Sawbones implanted with a 125° cephalomedullary nail were taken in 90 different postures: neutral, internal rotation/external rotation (0~60), flexion/extension (0~50), extension (5~20), and internal rotation (0~50). Then 3 orthopaedic surgeons measured SD using both traditional method and 3D method (Fig. 1).

Results: The measurement values by 3D method were close to the actual length regardless of the limb posture, with even less standard deviation. The SD was high when using the traditional method, especially when the nail (lower limb) rotates. The Pearson correlation coefficient showed positive correlation ($P < 0.001$) of the measurement values with variation of the C-arm positions when using the traditional method.

Conclusion: We conclude the traditional method of measuring SD is not accurate when the lower limb is rotated and/or flexed, while the 3D method is accurate in measuring the sliding distance of a lag screw regardless of the postures of the lower limb.

This is the Anteroposterior radiogram when the C-arm is external rotated by 40 degrees and the actual sliding length is 20mm
A: The sliding length is 16.191 mm by using the traditional method.
B: In MAYA scenograph view, 3D reconstruction model is changed X-ray mode which will completely match the nail image in the radiogram through spatial
Movement and lag screw's sliding.
C: The sliding distance of the lag screw will be measured on the coronal view of MAYA, the measurement value is 20.071mm

See pages 401 - 442 for financial disclosure information.

Schatzker Type IV Tibial Plateau Fractures with Lateral Condylar Involvement: A Subclassification Based on CT Morphology

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Purpose: Schatzker type IV tibial plateau fractures with lateral condylar involvement are a complex and fracture-dislocation injury, known as type B in AO/OTA classification. The aim of this study is to propose a new subclassification of the fractures patterns based on the analysis of CT morphology.

Methods: We collected the CT images of 47 consecutive cases of Schatzker type IV tibial plateau fractures with lateral condylar involvement (bicondylar type B) in 47 patients who had been treated at our department from July 2009 to December 2015. There were 31 males and 16 females, from 21 to 65 years of age (average, 48 years). All fractures were closed injury. We divided the articular surface of the tibial plateau into 4 quadrants, including anteromedial, posteromedial, anterolateral, and posterolateral. We recorded the location of fracture, the type of fracture, and the orientation of fracture line according to the anatomical area of tibial plateau bicondyle and 4 quadrants.

Results: In the 47 Schatzker type IV tibial plateau fractures with lateral condylar involvement (bicondylar type B), the fracture line was mostly oblique in both coronal and sagittal plane (44 cases, 94%). The fracture in lateral tibial plateau was majorly in the posterolateral quadrant. Schatzker type IV tibial plateau fractures with lateral condylar involvement can be classified into the following 4 subtypes: (A) Total medial condyle fracture with partial lateral condyle as an entire fragment (3 cases, 6%). The fracture line was sagittally present in anterolateral and posterolateral quadrants. (B) Posteromedial plateau fracture with posterolateral quadrant (20 cases, 43%). The fracture line was coronally present in posteromedial and posterolateral quadrants. (C) Total or subtotal medial condyle fracture with posterolateral quadrant (16 cases, 34%). The fracture line was diagonally present in anteromedial, posteromedial, and posterolateral quadrants. (D) Comminuted medial condyle fracture with posterolateral quadrant (8 cases, 17%). The fracture line was multiaxially present in anteromedial, posteromedial, and posterolateral quadrants.

Conclusion: Schatzker type IV tibial plateau fractures with lateral condylar involvement (bicondylar type B) can be classified into 4 subtypes. Based on the new subclassification, complex Schatzker type IV tibial plateau fractures can be more thoroughly understood and reasonably treated. The surgeon can choose position, approach, and fixation.

Osseointegrated Implants for Lower Limb Amputees: Evaluation of Bone Mineral Density

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Purpose: The use of dual-energy x-ray absorptiometry (DXA) is a standard clinical procedure for the evaluation of bone mineral density (BMD). Amputee patients are known to have decreased BMD and an increased risk of osteoporosis in the affected proximal femur and hip region. The major cause of these issues in these patients is the absence of adequate loading leading to bone resorption in accordance to Wolff's law. We present a prospective study reporting changes in BMD among amputees who received osseointegrated implants to determine if the loading through the osseointegrated implant can overcome the bone resorption issues.

Methods: This is a prospective study of 33 patients, consisting of 24 males and 9 females, aged 22-77 (mean = 51.0 ± -2.0) years with 1 and 2-year follow-up. Selection criteria included age over 18 years, unilateral amputees with socket-related problems. All patients received osseointegrated implants press-fitted into the amputated limb. BMD was assessed using DXA in the femoral neck (operative and contralateral) and lumbar spine (L2-L4) regions, and corresponding Z-scores were generated. DXA scans were taken preoperatively as well as 1 year and 2 years following osseointegration surgery.

Results: Mean BMD and Z-scores of spine, and operative and contralateral sides, were generated for all patients. Dependent t tests were used to test for significant differences ($P < 0.05$) preoperative, 1 year, and 2 years for mean changes in BMD and Z-scores following surgery. Analysis of the BMD and Z-scores indicated that patients showed improvements at 1 year post surgery.

Conclusion: These results suggest that osseointegrated implants are effective at encouraging bone growth and restoring BMD levels for amputees within a short period of time post surgery. Osseointegrated implants therefore have the potential to address stress distribution issues associated with socket prostheses and restore the normal bone-loading regime in lower limb amputees.

See pages 401 - 442 for financial disclosure information.

Orthopaedic Traumatologist Preference for Use of Regional Anesthesia in Fracture Management: A Survey of OTA Members

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Purpose: The purpose of this study was to evaluate orthopaedic traumatologists' use of regional anesthesia (RA) based on patient age, fracture pattern, location, and injury mechanism. A secondary outcome was to determine the prevalence of morbidity seen as a direct result of RA use—specifically, a missed compartment syndrome.

Methods: A prospective electronic survey was designed and a link placed on the OTA website. 13 clinical scenarios involving lower extremity injuries that detailed patient age, mechanism of injury, and fracture pattern were presented to OTA members. Members were given the option of using RA or forgoing its use. If RA was selected, participants then chose between the use of spinal anesthesia, one shot peripheral nerve injection, or continuous nerve catheter infusion. OTA members were also asked to complete questions pertaining to their clinical experience with RA masking compartment syndrome or delaying a diagnosis.

Results: A total of 30 OTA members completed the survey. There was a subgroup of respondents (6.6%) that do not use RA in their fracture practice regardless of the clinical scenario. The 2 fracture patterns for which >90% off the respondents would not consider any form of RA were high-energy tibial plateau fractures and tibial shaft fractures. The use of RA in other clinical scenarios varied greatly among those surveyed. With regard to the morbidity associated with RA use in fracture care, 65.5% of respondents declared they have seen the signs of compartment syndrome masked by regional blockade. Furthermore, 55.1% said they have been involved with a case where fasciotomies were performed for compartment syndrome in a patient who received RA.

Conclusion: The overwhelming majority of responding OTA members viewed high-energy tibial plateau and shaft fractures as contraindications to the use of RA. Evolving soft-tissue injury and compartment syndrome can be masked by the use of RA and may preclude the use of RA in certain fracture patterns. The results of this study highlight the importance of teamwork and communication necessary between anesthesiologists and orthopaedic surgeons to appropriately risk stratify which patients can safely be administered RA.

A Randomised Controlled Trial Comparing the Thompsons Versus the Exeter® Polished Taper Stem and Unitrax® Head in the Treatment of Displaced Intracapsular Fractures of the Hip: The WHiTE 3: HEMI Trial

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Purpose: Our objective was to compare the change in health-related quality of life of patients receiving a traditional cemented monoblock Thompson hemiarthroplasty versus a modern cemented modular polished taper stem hemiarthroplasty for displaced intracapsular fractures of the hip.

Methods: This was a pragmatic, multicenter, multisurgeon, 2-arm, parallel group, randomized standard-of-care controlled trial. It was embedded within the WHiTE (World Hip Trauma Evaluation) Comprehensive Cohort Study. The trial was conducted on an intention-to-treat (ITT) basis. Five NHS trauma centers in England, UK undertook patient recruitment. The sample size was 964 patients. Hip fracture patients presenting to participating trusts between February 2015 and March 2016, over 60 years of age, and requiring hemiarthroplasty of the hip were eligible for recruitment. The main outcome measure was the EQ-5D-5L questionnaire, carried out on admission and at 4 months postoperation.

Results: The adjusted EQ-5D-5L at 4 months excluding mortality is 0.045 (95% confidence interval [CI] -0.007 to 0.098); P = 0.09. This decreases to 0.037 (95% CI -0.014 to 0.087; P = 0.156) when mortality is included. The minimum clinically important difference for EQ-5D-5L used in this study is 0.08; therefore any benefit between implants is unlikely to be noticeable by the patient. There is no difference in mortality or mobilization at this time point. There is a small benefit in length of stay in favur of the Exeter stem with a Unitrax head during the initial hospital admission.

Conclusion: Contrary to the current NICE (National Institute for Health and Clinical Excellence) Hip Fracture Guidelines, the use of the traditional Thompson hemiarthroplasty in the treatment of the displaced intracapsular hip fracture shows no difference in comparison to the recommended modern cemented hemiarthroplasty.

See pages 401 - 442 for financial disclosure information.

Circumferential Bone Graft Around an Absorbable Gelatin Sponge Core Reduced the Amount of Grafted Bone in the Induced-Membrane Technique for Critical-Size Defects of Long Bones

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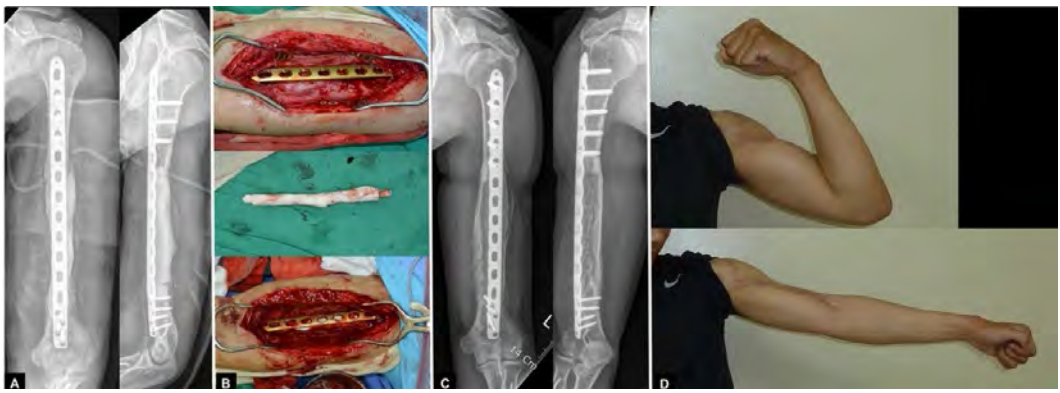
Purpose: The aims of the study were to introduce a circumferential bone graft around an absorbable gelatin sponge core using induced-membrane technique, to assess its ability to reduce the required amount of graft, and to maintain the bone graft.

Methods: This was a retrospective review of prospectively collected data at a urban university medical center. The central core of defect was filled with absorbable gelatin sponge. The gel foam core was surrounded with the harvested autogenous bone like a shell. The serial 3-dimensional (3D) model was configured by virtual 3D software to verify if the circumferential bone graft could be maintained properly. The volumetric measurements of defect size, proportion of gelatin sponge, and amount of grafted bone was done. The resorption of grafted bone were calculated comparing each serial CT scan and 3D model to verify if the circumferential bone graft could be incorporated well.

Results: The critical-size defect was located at the metadiaphyseal area of 11 tibias, 8 femurs, and 2 humeri. The average defect size was 8.9 cm in length and 65.2 cm^3 in volume. The absorbable gelatin sponge core replaced 21.4% (average) of the defect volume. There was no significant deterioration in the shape of grafted bone between serial 3D models. 18 patients (86%) were healed radiographically at 9.1 months.

Conclusion: Our study suggests that circumferential bone grafting in association with induced-membrane technique could reduce the required amount of bone graft and adequately maintain graft position and shape, with favorable clinical results.



The Value of 3D-Printed Models and Virtual Reality in Understanding Acetabular Fractures

Lars Brouwers, PhD Student[1]*; Albert Pull Ter Gunne, MD PhD*[2]*; Mariska de Jongh, PhD*[1]*; Mike Bemelman, MD*[2]*; Koen Lansink, MD, PhD*[2]

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Purpose: Acetabular fractures are complex and difficult to classify. Although the Judet-Letournel classification is designed to increase the understanding of acetabular fractures, it remains prone to error when using conventional medical imaging. We hypothesize that 3-dimensional (3D) printing and virtual reality (VR), as new diagnostic imaging tools, will lead to an increased understanding and knowledge about the acetabular fracture and surgical approach.

Methods: Digital data (DICOM [Digital Imaging and Communications in Medicine]) of 20 acetabular fractures was converted into 3D files (STL [stereolithography] data). These STL files were used to prepare 3D prints of life-size hemi-pelvic models with acetabular fractures and files for a mobile VR headset. Seven senior trauma surgeons specialized in pelvic and acetabular surgery, 5 young fellowship-trained trauma surgeons, 5 senior surgical residents, 5 junior surgical residents, and 5 interns classified 20 acetabular cases using radiographs/2D CT, 3D reconstructions, 3D printing, and VR according to the Judet-Letournel classification. Furthermore, all junior and senior surgeons were instructed to evaluate their surgical approach and positioning of the patient during operation. Time to classify each case was recorded. Calculations were done using Fleiss kappa statistics.

Results: Only slight and fair interobserver agreements for senior surgeons ($\kappa = 0.33$) and interns ($\kappa = 0.16$) were found when using radiographs/2D CT. However, 3D printing showed moderate and substantial interobserver agreements for senior surgeons ($\kappa = 0.59$), junior surgeons($\kappa = 0.56$), senior surgical residents ($\kappa = 0.66$), junior surgical residents ($\kappa = 0.51$), and interns ($\kappa = 0.61$), while VR showed a clear decrease in interobserver agreements for senior surgeons ($\kappa = 0.42$). Compared with radiographs/2D CT, the interobserver agreements on the surgical approach for junior surgeons using 3D printed models and VR increased, respectively, $\kappa = 0.04$, $\kappa = 0.23$, and $\kappa = 0.17$. Except for the interns, a significant time difference between radiographs/2D CT and 3D CT - 3D print - VR was found for junior and senior surgical residents and junior and senior surgeons ($P < 0.001$).

Conclusion: 3D printing is of added value in understanding, classification, and surgical evaluation of acetabular fractures, whereas VR is of added value for the future generation trauma surgeons. We recommend implementation of 3D printed models and VR into trauma surgery training.

See pages 401 - 442 for financial disclosure information.

Investigating the "Weekend Effect" in a Serial Prospective Cohort of 29,465 Trauma Patients

Tanvir Khan, MBBS[1]*; Katie Elisabeth Rollins; Joanne Morling, PhD*[1]*; Dileep Lobo, MD*[1]*; Daren P. Forward; Brigitte Scammell; Benjamin Ollivere*

[1]*University of Nottingham, Nottingham, Nottinghamshire, UNITED KINGDOM*

Purpose: There is increasing evidence supporting an association between hospital admission during the weekend and a higher risk of death compared with weekday admission. Our primary aim was to explore the association between weekend admission with trauma and the 30-day mortality, and to examine which patient and care-related factors influence this association. The secondary aim was to investigate if early consultant/attending clinician input after admission influenced the risk of 30-day mortality, independent of day of admission.

Methods: We performed an outcomes study of all trauma admissions to our Level I trauma center between June 2001 and December 2013 using data collected prospectively. Univariate and multivariate Cox proportional hazards models were used to compare the risk of 30-day mortality for weekend (Friday 18:00 to Monday 7:59) versus weekday admission (Monday 8:00 to Friday 17:59) and the association reported as hazard ratios (HRs). The association between early consultant/attending clinician input irrespective of day of admission and 30-day mortality was determined using multivariate models.

Results: For trauma admissions overall, there was no significant association between weekend compared to weekday admission and risk of 30-day mortality (HR 1.04, 95% confidence interval [CI] 0.96 to 1.12). Subgroup analysis demonstrated similar findings for polytrauma admissions (HR 1.07, 95% CI 0.87 to 1.31) and orthopaedic trauma admissions (HR 0.97, 95% CI 0.89 to 1.07). For hip fracture admissions, there was a significantly higher risk of 30-day mortality for patients admitted over the weekend (HR 1.19, 95% CI 1.04 to 1.36). For all cohorts, independent of weekend admission, there was a significant association between early consultant/attending clinician input and decreased risk of 30-day mortality. The corresponding HRs were: 0.799 (95% CI 0.640 to 0.998; P = 0.048) for polytrauma admissions, 0.822 (95% CI 0.720 to 0.938; P = 0.004) for orthopaedic trauma admissions, and 0.230 (95% CI 0.150 to 0.353; P <0.0001) for hip fracture admissions.

Conclusion: With the exception of hip fracture patients there was no increased risk of 30-day mortality for trauma patients admitted at the weekend, suggesting the association is condition-specific. With respect to hip fractures, there is a need to minimize the time between admission and surgery. Early consultant input independently reduces mortality risk and is a key marker of care for trauma patients.

Abbott, Matthew	*(n)*
Abdelgawad, Amr	*1 (Springer)*
Abdel-Ghany, Mahmoud	*(n)*
Acharya, Mehool	*3B (Stryker consultant for education and training)*
Achor, Timothy	*2 (Depuy Synthes)*
Achors, Kyle	*(n)*
Achten, Juul	*(n)*
Acuna, Anabel	*(n)*
Adams, John	*(n)*
Adams, Mark	*(n)*
Adler, Jeremy	*(n)*
Agarwal, Animesh	*2 (Acelity, Smith & nephew); 3B (Acelity, Smith & Nephew, BRC); 5 (Fortify, METRC); 7 (Springer); 8 (JOT); 9 (JOT, AAOS, OTA)*
Agarwala, Anshul	*(n)*
Agel, Julie	*(n)*
Ahmed, Issaq	*(n)*
Ahn, Hyunhee	*(n)*
Aibinder, William	*(n)*
Aiken, Marc	*(n)*
Aitken, Stuart	*(n)*
Akbar, Adam	*(n)*
Al Muderis, Munjed	*4 (Osseointegration International Pty Ltd (Australia); AQ Implants GmbH (Germany); Permedica S.p.a (Italy))*
Al-Asiri, Jamal	*(n)*
Alhoukail, Amro	*(n)*
Ali, Ashley	*(n)*
Ali, Imran	*(n)*
Ali, Sayed	*(n)*
Almhadi, Waleed	*(n)*
Altman, Gregory T	*(n)*
Alvarez-Nebreda, Maria Loreto	*(n)*
Amanatullah, Derek	*3B (Stryker, Exactech, Omni, BlueJay Mobile Health); 3C (None); 4 (None); 5 (Acumed, Stryker, BlueJay Mobile Health); 8 (Medscape); 9 (MSIS - International Consensus on Periprosthetic Joint Infection, AAOS - Basic Science Evaluation Committee, ASMBS Obesity Summit - AAOS Rep)*
Ambler, Melanie	*(n)*
Amorosa, Louis	*(n)*
An, Howard	*1 (Zimmer Spine Inc., U&I Inc.); 3B (Bioventus, Inc.); 4 (Medyssey Inc, Spinal Kinetics Inc.); 5 (Spinalcytes Inc.)*

Disclosure:
(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. *= Not available at time of printing. Refer to pages 463 - 465.

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DISCLOSURE LISTING – ALPHABETICAL

Anakwe, Raymond	*(n)*
Anders, Mark	*(n)*
Andrade-Silva, Fernando	*(n)*
Aneja, Arun	*(n)*
Anglen, Jeffrey	*(n)*
Annan, John	*(n)*
Appleton, Paul	*(n)*
Archdeacon, Michael	*1 (Slack Inc. / Stryker); 2 (Stryker); 3B (Stryker); 9 (Ohio Orthopaedic Society/ President Elect 2017-2019)*
Archer, Kristin	*(n)*
Arkader, Alexandre	*3C (surgical advisory board Orthopediatrics)*
Arsoy, Diren	*(n)*
Arthur, Calum	*(n)*
Asprinio, David	*(n)*
Au, Brigham	*(n)*
Audet, Megan	*(n)*
Augat, Peter	*(n)*
Auston, Darryl	*(n)*
Avilucea, Frank	*2 (Zimmer-Biomet)*
Awad, Hani	*(n)*
Azizi, Jahan	*3B (EDGe Surgical)*
Babhulkar, Sushrut	*(n)*
Backes, Manouk	*(n)*
Bakker, Fred	*(n)*
Bala, Abiram	*(n)*
Baldwin, Keith	*7 (Journal of Bone and Joint Surgery - American); 3B (Pfizer); 4 (Pfizer); 3B (Synthes Trauma)*
Barcak, Eric	*(n)*
Barei, David	*3B (Depuy Synthes)*
Barla, Jorge	*2 (DePuy Synthes)*
Barnwell, Jonathan	*(n)*
Barr, R John	*(n)*
Bartlett, Craig	*2 (AO Trauma); 3B (SI Bone; Stryker Medical); 4 (JNJ; MRK; ABBV); 8 (JOT editorial board)*
Basile, Ralph	*3A (Healthmark Industries Company, Inc, Fraser, MI); 4 (Healthmark Industries Company, Inc, Fraser, MI)*
Basmajian, Hrayr	*3B (Smith and Nephew; Accumed; Orthofix)*
Bassett, James	*(n)*
Bassuener, Scott	*(n)*
Bates, Brent	*(n)*

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Batty, Miles	*(n)*
Baumgaertner, Michael	*9 (AO North America 501(c)3)*
Baynard, Taurean	*(n)*
Beaupre, Lauren	*(n)*
Beck, Chad	*(n)*
Bedard, Nicholas	*(n)*
Beebe, Michael	*(n)*
Beigler, David	*(n)*
Beimel, Claudia	*3A (Stryker)*
Belayneh, Rebekah	*(n)*
Bell, Katrina	*(n)*
Bellamy, Joseph	*(n)*
Bellevue, Kate	*(n)*
Bellino, Michael	*(n)*
Beltran, Michael	*(n)*
Bemelman, Mike	*2 (Depuy Synthes); 3B (Depuy Synthes); 6 (Makerbot Ultimaker); 9 (ESTES)*
Bender, Mark	*(n)*
Benirschke, Stephen	*(n)*
Benoit, Herbert	*(n)*
Berasi, Stephen	*3A (Pfizer Inc); 4 (Pfizer Inc)*
Bere, Tone	*(n)*
Berger, Amy	*(n)*
Berger, Peter	*(n)*
Bergeron, Stephane	*(n)*
Bergin, Patrick	*3B (Accumed, Synthes)*
Berhaneselase, Eleni	*(n)*
Berry, Gregory	*(n)*
Bethea, Audis	*(n)*
Beynnon, Bruce	*(n)*
Bhandari, Mohit	*3B (Smith and Nephew, Stryker, Amgen, Zimmer, Moximed, Bioventus, Merck, Eli Lily, Sanofi, ConMed, Ferring, DJO); 5 (Stryker, Zimmer, Amgen, Smith and Nephew, DePuy, Eli Lily, Bioventus)*
Bhashyam, Abhiram	*(n)*
Billard, Kristi	*(n)*
Billiar, Timothy	*(n)*
Billow, Damien	*(n)*
Bishop, Julius	*1 (Innomed); 3B (Globus Medical); 5 (Zimmer)*
Black, James	*(n)*

Disclosure:
(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. *= Not available at time of printing. Refer to pages 463 - 465.

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DISCLOSURE LISTING – ALPHABETICAL

Blair, James	*9 (Orthopaedic Trauma Association; Society of Military Orthopaedic Surgeons)*
Blais, Micah	*(n)*
Blankstein, Michael	*4 (7D surgical)*
Bleeker, Nils Jan	*(n)*
Blitzer, Charles	*(n)*
Bloemers, Frank	*(n)*
Blom, Robin	*(n)*
Boateng, Henry	*(n)*
Bogdan, Yelena	*9 (OTA fellowship committee; COTA board of directors member at large)*
Bohner, Marc	*3B (Mathys Ltd. BioVentus.); 4 (J&J.); 5 (Mathys Ltd.); 7 (Editor of Acta Biomaterialia (Elsevier Journal))*
Bonness, Eric	*(n)*
Bonyun, Marissa	*(n)*
Boone, Myles	*(n)*
Borland, Steven	*(n)*
Born, Christopher	*2 (Stryker Trauma); 3B (Stryker Orthopaedics, Illuminoss); 3C (Biointraface,); 4 (Biointraface, Illuminoss); 5 (Stryker Spine); 9 (OTA, FOT, AAOS)*
Borrelli, Joseph	*2 (Eli Lilly);*
Bosco, Joseph	*1 (Genovel); 2 (Paciera); 3B (Medtronic, Surgical directions, Labrador Partners); 8 (Bulletin Hospital for Joint Diseases); 9 (OLC, APIC)*
Bosse, Michael	*4 (Orthopaedic Implant Company)*
Bottlang, Michael	*1 (Synthes, Zimmer Biomet, Sam Medical); 2 (Zimmer Biomet); 5 (Zimmer Biomet);*
Bouillon, Bertil	*(n)*
Box, Hayden	*(n)*
Boyer, Martin	*7 (Thieme, Wolters Kluwer Publishing); 8 (American Society for Surgery of the Hand); 9 (Americal Society for Surgery of the Hand (several committees))*
Bradaschia Correa, Vivian	*(n)*
Bramer, Michelle	*(n)*
Brand, Andreas	*(n)*
Bravo, Dalibel	*(n)*
Breederveld, Roelf	*(n)*
Breslin, Mary	*(n)*
Briet, Jan	*(n)*
Brinker, Mark	*1 (Zimmer/Biomet);*
Britten, Simon	*6 (Smith and Nephew, Stryker);*
Brock, J. Logan	*3B (EDGe Surgical, Inc.); 4 (EDGe Surgical, Inc.);*
Broderick, J	*2 (AONA); 9 (Orthopaedic Trauma Association, South Carolina Orthopaedic Association)*
Brodke, Dane	*3b (Valium); 7 (Amedica, Medtronic); 8 (Clinical Orthopaedics and Related Research); 9 (AOSpine, Cervical Spine Research Society, Lumbar Spine Research Society)*

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Broekhuyse, H	*8 (Journal of Orthopaedic Trauma (editorial board))*
Brooks, Johnell	*1 (DriveSafety); 5 (DriveSafety);*
Brouwers, Lars	*5 (Project no AOTEU-R-2016-050 was supported by AOTRAUMA Switzerland; KNMG stimuleringsfonds);*
Brown, Alexander	*(n)*
Brown, Bryan	*(n)*
Bruce, Julie	*(n)*
Bruggers, Jennifer	*(n)*
Bruntink, Marlieke	*5 (Glaxo Smith Kline)*
Bryant, Diane	*(n)*
Buck, J. Stewart	*(n)*
Buckley, Andrew	*(n)*
Buckley, Richard	*(n)*
Bugler, Kate	*(n)*
Bui, Christopher	*(n)*
Burns, James	*(n)*
Buser, Zorica	*3B (Xenco Medical (current), AOSpine (past))*
Butterfield, Warren	*(n)*
Byrd, Zackary	*(n)*
Byrne, James	*(n)*
Bzovsky, Sofia	*(n)*
Caballero, Jesse	*(n)*
Cady, Nathaniel	*(n)*
Cafri, Guy	*(n)*
Caird, Michelle	*8 (volunteer – editorial board member of the Journal of Pediatric Orthopaedics); 9 (chair research committee POSNA, member annual program committee POSNA, member research development committee AAOS, member of fellowship committee (membership) SRS)*
Cairns, Mark	*(n)*
Calder, Mark	*(n)*
Caldwell, Ryan	*(n)*
Callaghan, John	*1 (DePuy (for intellectual property transfer for hip and knee implant designs)); 3B (DePuy (for intellectual property transfer for hip and knee implant designs)); 7 (Wolters Kluwer (for books edited)); 8 (Journal of Arthroplasty); 9 (International Hip Society, OREF, Knee Society)*
Campbell, John	*3A (Synergy Surgicalists); 4 (Synergy Surgicalists)*
Canadian Orthopaedic Trauma Society, (COTS)	*5 (Synthes, Smith & Nephew, Stryker)*
Cannada, Lisa	*(n)*
Capo, John	*3b (Valium); 7 (Amedica, Medtronic); 8 (Clinical Orthopaedics and Related Research); 9 (AOSpine, Cervical Spine Research Society, Lumbar Spine Research Society)*

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Carabelli, Guido	*(n)*
Carey, Timothy	*(n)*
Carlini, Anthony	*(n)*
Carolan, Gregory	*2 (Depuy/Mitek); 3B (Depuy/Mitek); 8 (The Journal of Arthroscopic Surgery and Related Research)*
Caronis, Gregory	*3B (Centric Medical)*
Caroom, Cyrus	*3C (DePuy Synthes)*
Carroll, Eben	*(n)*
Carter, Tom	*(n)*
Caruso, Arianna	*(n)*
Carvalho, Adriana	*(n)*
Cass, Joseph	*(n)*
Castana, Penelope	*(n)*
Castano, Daniel	*(n)*
Castillo, Renan	*(n)*
Caswell, Kathleen (OTA Staff)	*(n)*
Cavallero, Matthew	*(n)*
Cazzulino, Alejandro	*(n)*
Chadayammuri, Vivek	*(n)*
Chan, Andrea	*(n)*
Chang, Shi-Min	*(n)*
Changoor, Stuart	*(n)*
Charlu, Jonathan	*(n)*
Chau, Michael	*(n)*
Chaus, George	*5 (AO North America Fellows Grant to conduct a study on distal femur fractures. Unrelated to this study.)*
Chen, Eric	*(n)*
Cherney, Steven	*(n)*
Chesser, Tim	*2 (Stryker); 3B (Stryker, Acumed); 9 (Orthopaedic Trauma Society, National Hip Fracture Database, British Orthopaedic Association Trauma Group)*
Childs, Benjamin	*(n)*
Cho, Jae-Woo	*(n)*
Cho, Won-Tae	*(n)*
Choi, Paul	*(n)*
Chokotho, Linda	*(n)*
Chrea, Bopha	*(n)*
Christ, Alexander	*(n)*
Christian, Matthew	*(n)*

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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 463 - 465.

Chung, Andrew	*(n)*
Churchman, Sarah	*(n)*
Cintean, Raffael	*(n)*
Clark, Kurt	*(n)*
Clarke-Jenssen, John	*9 (Chairman, Norwegian association for Orthopaedic Traumatology)*
Clement, Nicholas	*(n)*
Clement, R.	*(n)*
Coale, Max	*(n)*
Cochran, Grant	*(n)*
Codesido, Mariano	*(n)*
Cohen, Joseph	*(n)*
Cole, Peter	*2 (AO Trauma); 4 (BoneFoam, Inc.); 5 (Depuy-Synthes, Stryker)*
Coles, Chad	*2 (Zimmer Biomet); 5 (Depuy Synthes, Zimmer Biomet, Smith and Nephew, Stryker); 8 (Journal of Orthopaedic Trauma, Injury, Canadian Journal of Surgery); 9 (Canadian Orthopaedic Foundation, Canadian Orthopaedic Association, OTA)*
Coll, Daniel	*3B (One time payment for Pacira Pharmaceuticals Provider Group Consultation); 4 (Merck Medical-Common Stock; Orthopaedic Implant Company-Common Stock); 9 (Ex Oficio Member of OTA Education Committee)*
Collette, Andrew	*(n)*
Collinge, Cory	*1 (DePuy-Synthes, Zimmer-Biomet, Advanced Orthopedic Solutions, Smith & Nephew); 3B (Stryker, Zimmer-Biomet); 8 (Journal Orthopedic Trauma, JAAOS); 9 (Foundation for Orthopedic Trauma)*
Collins, Susan	*(n)*
Connelly, Daniel	*(n)*
Conway, Devin	*(n)*
Cook, James	*1 (Arthrex, Inc.); 2 (Arthrex, Inc.); 3B (Arthrex, Inc.; CONMED Linvatec; Eli Lilly; Schwartz Biomedical); 5 (Arthrex, Inc.; Coulter Foundation; DePuy Synthes; Musculoskeletal Transplant Foundation; National Institutes of Health; Nutramax; U.S. Department of Defense; Zimmer); 7 (Thieme Medical Publishers); 8 (Journal of Knee Surgery); 9 (Musculoskeletal Transplant Foundation)*
Cooke, Margaret	*(n)*
Copeland, Carol	*(n)*
Copp, Jonathan	*(n)*
Corey, Robert	*(n)*
Corona, Benjamin	*(n)*
Corrigan, Chad	*2 (AO North America Faculty)*
Cortez, Abigail	*(n)*
Cosgrove, Christopher	*(n)*
Costa, Matthew	*(n)*
Cota, Adam	*(n)*
Cothren Burlew, Clay	*(n)*

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Cotton, Bryan	*3B (Haemonetics Corp. Braintree, MA)*
Coughlin, R	*(n)*
Craig, Julie	*(n)*
Creevy, William	*9 (AAOS; Orthopaedic Trauma Association)*
Crichlow, Renn	*2 (Synthes); 4 (Stryker); 8 (Journal of Orthopaedics and Traumatology, Journal of Trauma, Orthopedics)*
Criner, Seth	*(n)*
Cripps, Michael	*(n)*
Cripton, Peter	*(n)*
Crist, Brett (Program Committee)	*2 (Acelity; AO Foundation); 3B (Acelity, Globus, DePuy Synthes, SMV); 4 (Orthopaedic Implant Company, Amedica); 5 (Acelity); 8 (Journal of Orthopaedic Trauma, Journal of Hip Preservation); 9 (OTA, MAOA, AOTNA, IGFS)*
Cristofolini, Luca	*5 (Adler Ortho, Aesculap/B.Braun, Tecres SpA (Verona, Italy)); 8 (Journal of Biomechanics (Elsevier), Medical Engineering & Physics (Elsevier)*
Crookshank, Meghan	*(n)*
Cross, William	*(n)*
Cummings, Olivia	*(n)*
Cunningham, Brian	*3A (Wife, Breanna Cunningham, CEO & Founder, CODE Technology); 3C (CODE Technology); 4 (Wife, Breanna Cunningham, CEO & Founder, CODE Technology)*
Cunningham, Bryce	*(n)*
Cuthbert, Richard	*(n)*
Cutshall, Andrew	*(n)*
Daccarett, Miguel	*(n)*
Dahl, Reena	*(n)*
Dahl, Tyler	*(n)*
Dailey, Steven	*(n)*
Daluiski, Aaron	*9 (American Board of Orthopaedic Surgery, Inc; American Society for Surgery of the Hand, Journal of Hand Surgery – American)*
Daniels, Alan	*3B (Stryker, Globus, Orthofix, Spineart); 5 (Orthofix); 7 (Springer)*
D'Aquilla, Kevin	*(n)*
Daurka, Jasvinder	*(n)*
Davidovitch, Roy	*3B (Medtronic, Radlink); 7 (Radlink)*
Davis, Elizabeth	*(n)*
Davis, Jacob	*(n)*
Davis, Jason	*(n)*
Dawson, Sarah	*(n)*
Day, Brian	*8 (BC Medical Journal)*
de Jongh, Mariska	*(n)*
De La Huerta, Fernando	*2 (Zimmer Biomet)*

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De Muinck Keizer, Robert-Jan	*(n)*
De Ridder, Victor	*(n)*
Deafenbaugh, Bradley	*(n)*
DeBritz, James	*(n)*
Decker, Summer	*(n)*
DeCoster, Thomas	*3B (Toxicology Management Services); 4(Merck); 8 (Journal of Bone and Joint Surgery – American); 9 (Orthopaedic Trauma Association)*
Dehghan, Niloofar	*1 (Stryker); 3B (Zimmer, ITS, Acumed); 5 (OTA, PSI, CIHR, Biventus); 7 (LWW, Elsevier); 8 (JOT, Orthopaedics today); 9 (OTA)*
Del Core, Michael	*(n)*
Delarosa, Matthew	*(n)*
Della Rocca, Gregory (Program Committee)	*1 (Wright-Tornier); 2 (DePuy-Synthes); 3B (Bioventus); 4 (Amedica, The Orthopaedic Implant Company, Mergenet Medical, LuminCare); 5 (DePuy-synthes); 8 (Journal of Orthopaedic Trauma); 9 (Orthopaedic Trauma Association, American College of Surgeons, American Orthopaedic Association, AOTrauma North America, American Academy of Orthopaedic Surgeons)*
Delong, William	*(n)*
Demik, David	*(n)*
Den Hartog, Dennis	*9 (Dutch Trauma Society)*
Deo, Sandeep	*2 (Stryker UK, Zimmer-Biomet UK)*
Deren, Matthew	*(n)*
Derksen, Robert Jan	*(n)*
Desai, Bharat	*(3B (SI-Bone; Zimmer)*
DeSanto, Jennifer	*(n)*
Deunk, Jaap	*(n)*
DeVos, Marijke	*(n)*
Di, Junrui	*(n)*
Diaz, Miguel	*(n)*
Dingemans, Siem	*(n)*
DiPasquale, Thomas	*(n)*
Do, Andrew	*(n)*
Donegan, Derek	*2 (AONA); 3B (Depuy Synthes)*
Donnelly, Kevin	*(n)*
Donohue, David	*(n)*
Doornberg, Job	*(n)*
Doro, Christopher	*(n)*
Drayton, Khalil	*(n)*
Drazan, John	*(n)*
Dressler, Brent	*(n)*
Dube, Vincent	*(n)*

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Dubin, Jonathan	*9 (Missouri State Orthopedic Association – Secretary of the Board)*
Duckworth, Andrew	*(n)*
Duffy, Paul	*(n)*
Dugarte, Anthony	*(n)*
Dumpe, Jarrod	*(n)*
Dunbar, Kirstin	*(n)*
Dunbar, Robert	*6 (innovision Corp); 8(Journal of Orthopaedics and Traumatology, OrthoInfo); 9 (AAOS)*
Dyer, George	*2 (DJO); 6 (Support to orthopaedic residency – Depuy Synthes, Stryker, Smith and Nephew)*
Eagleton, Connor	*(n)*
Eastman, Jonathan	*(n)*
Egol, Kenneth	*1 (Exactatech, Inc.); 3B (Exactatech, Inc.); 4 (Johnson and Johnson); 5 (Synthes); 7 (SLACK Incorporated; Wolters Kluwer Health – Lippincott Williams & Wilkins)*
Ehlert, Kurt	*(n)*
Ehrlichman, Lauren	*(n)*
Eickhoff, Alexander	*(n)*
Ekure, John	*(n)*
Eliezer, Edmund	*(n)*
Elkrief, Justin	*(n)*
Elliott, Iain	*(n)*
Elliott, Marilyn	*(n)*
Ellis, Henry	*2 (Smith and Nephew); 3B (Smith and Nephew)*
Elsorafy, Kareem	*(n)*
Emberton, Bonnie (OTA Staff)	*(n)*
Esposito, John	*(n)*
Evans, Douglas	*(n)*
Evens, Liz	*(n)*
Ewins, Emma	*(n)*
Fabricant, Peter	*(n)*
Farley, Frances	*(n)*
Farnsworth, Christopher	*(n)*
Farrelly, Erin	*(n)*
Faulkner, Alastair	*(n)*
Feldman, David	*3B; 7 (Orthopediatrics)*
Fergason, John	*(n)*
Fernandez, Miguel	*(n)*
Ficke, James	*8 (Southern Orthopaedic Association); 9 (American Orthopaedic Association- Leadership/ Fellowships Committee; Executive Committee)*
Fiedler, Carina	*(n)*

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Fineberg, Steven	*(n)*
Fink, Kyle	*(n)*
Finkemeier, Christopher	*2 (Depuy Synthes); 3B (Depuy Synthes)*
Finnan, Ryan	*(n)*
Firoozabadi, Reza	*3B (Smith & Nephew); 9 (OTA)*
Fiset, Sandra	*(n)*
Fitzpatrick, Daniel	*1 (Synthes CMF, Zimmer Biomet); 2 (Zimmer Biomet)*
Flacke, Sebastian	*(n)*
Flanagan, Christopher	*(n)*
Fleps, Ingmar	*(n)*
Flint, Kathy	*(n)*
FLOW Investigators	*(n)*
Floyd, John	*4 (Carbofix)*
Foley, Robert	*(n)*
Ford, Jonathan	*(n)*
Forward, Daren	*(n)*
Foster, Andrew	*(n)*
Foster, Brock	*(n)*
Foster, Patrick	*(n)*
Fourman, Mitchell	*(n)*
Fowler, Justin	*(n)*
France, John	*(n)*
Francis, Jeffrey	*(n)*
Frank, Matthew	*(n)*
Freibott, Christina	*(n)*
Frey, Katherine	*(n)*
Friess, Darin	*3B (Acumed, LLC)*
Fry, Michael	*(n)*
Fulkerson, Eric	*3B (Conventus Orthopaedics)*
Funk, Shawn	*(n)*
Furman, B	*(n)*
Gael, Sarah	*(n)*
Gage, Mark	*(n)*
Gales, Jordan	*(n)*
Gallagher, Anthony	*7 (Springer)*
Gallagher, Bethany	*(n)*
Gallino, Rafael	*(n)*

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Galos, David	*(n)*
Gamulin, Axel	*(n)*
Gangavalli, Anup	*(n)*
Gangler, Jennifer (OTA Staff)	*(n)*
Gao, Yubo	*(n)*
Garcia, Dioscaris	*3A (Materials science associates); 3B (Materials science associates)*
Gardezi, Mursal	*(n)*
Gardner, Michael J (Program Committee)	*2 (Miami Medical); 3B (Biocomposites; BoneSupport AB; KCI; Pacira Pharmaceuticals; DePuy Synthes); 4 (Imagen Technologies; Conventus); 5 (DePuy Synthes); 7 (JBJS, Lippincott); 8 (Journal of Orthopaedic Trauma; Current Opinion in Orthopaedics); 9 (Orthopaedic Trauma Association; American Orthopaedic Association; Orthopaedic Research Society)*
Gardner, Warren	*(n)*
Garfi, John	*(n)*
Garner, Matthew	*(n)*
Garven, Alexandra	*(n)*
Gary, Joshua	*2 (Smith and Nephew; AO); 3B (None); 4 (SMV Scientific); 5 (AO); 8 (JBJS and JOT); 9 (OTA and AO)*
Gausden, Elizabeth	*(n)*
Gavaskar, Ashok	*(n)*
Gebhard, Florian	*9 (German Trauma Society, AO Foundation)*
Gebrelul, Aaron	*(n)*
Gehling, Paxton	*(n)*
Germany, Lauren	*(n)*
Geusens, Eric	*(n)*
Ghayoumi, Pouriya	*(n)*
Giannoudis, Peter	*1 (Zimmer Biomet); 2 (Zimmer Biomet); 5 (Stryker, Zimmer Biomet, Depuy Synthes); 8 (Injury)*
Giannoudis, Vasileios	*2 (Smith & Nephew); 3B (Zimmer-Biomet, Stryker, DePuy-Synthes); 5 (Zimmer-Biomet, Stryker, DePuy-Synthes); 8 (Injury)*
Gil, Joseph	*(n)*
Gilbertson, Jeff	*(n)*
Gill, Emma	*(n)*
Gill, Steven	*(n)*
Gitajn, Ida Leah	*(n)*
Githens, Michael	*(n)*
Gladden, Paul	*(n)*
Glatt, Vaida	*(n)*
Godbout, Charles	*(n)*
Godfried, David	*(n)*
Gofton, Wade	*2, 3B (Microport, Zimmer); 6 (Synthes)*

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Goldman, Brian	*(n)*
Gonzalez, Leah	*(n)*
Goodman, Avi	*(n)*
Goodman, Stuart	*(n)*
Goodwin, Alexandra	*(n)*
Gorczyca, John	*(n)*
Gordon, Matthew	*(n)*
Gordon, Wade	*2 (Orthofix, LTD); 9 (OTA, AAOS)*
Gorman, Melissa	*(n)*
Gorman, Robert	*(n)*
Gortler, Hilary	*(n)*
Goslings, J Carel	*(n)*
Goudie, Ewan	*(n)*
Goudie, Stuart	*(n)*
Goulet, James	*7 (Zimmer); 9 (American Orthopaedic Association)*
Graves, Matt	*2 (DPS); 3B (DPS);*
Greenstein, Alexander	*(n)*
Gregory, Dennis	*3B (Acelity); 9 (Orthopaedic Trauma Association)*
Gregory, Paul	*(n)*
Greising, Sarah	*(n)*
Grier, Alex	*(n)*
Griffin, Xavier	*5 (This study was investigator initiated, industry funded, University sponsored)*
Griffith, Cullen	*(n)*
Grinberg, Orly	*(n)*
Gross, Jonathan	*(n)*
Gross, Jordan	*(n)*
Group, PRIMUM	
Beuhler, Michael	(n)
Bosse, Michael	*4 (Orthopaedic Implant Company)*
Gerkin, Emily	(n)
Gibbs, Michael	(n)
Griggs, Christopher	(n)
Jarrett, Steven	(n)
Runyon, Michael	*1 (Wolters Kluwer Health - Lippincott Williams & Wilkins); 5 (Boehringer Ingelheim Pharmaceuticals, Durata Therapeutics International, Janssen Pharmaceutica, Siemens Healthcare Diagnostics, Trinity Biotech); 8 (Academic Emergency Medicine); 9 (Pediatric Emergency Medicine sub-board of the American Board of Pediatrics)*
Saha, Animita	(n)

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Schiro, Sharon	(n)
Watlin, Bradley	(n)
Wyatt, Stepehn	(n)
Groutars, Yannick	*(n)*
Gruenwald, J	*(n)*
Gudeman, Andrew	*(n)*
Guerado, Enrique	*3B (Stryker); 9 (Sociedad Española de Cirugía Ortopédica y Traumatología)*
Guilak, F	*3B (Abbvie); 4(Active Implants Corp, Cytex Therapeutics); 8 (Osteoarthritis and Cartilage Journal of Biomechanics); 9 (Orthopaedic Research and Education Foundation, Orthopaedic Research Society);*
Guldberg, Robert	*(n)*
Guthrie, Stuart	*(n)*
Guy, P	*3B (Stryker); 4 (Traumis); 6 (Institutional financial support and in-kind research implant support: DePuy-Synthes); 9 (Canadian Orthopedic Foundation, Health and Mobility Society)*
Haac, Bryce	*(n)*
Haag, Adam	*(n)*
Hagedorn, John	*4 (Abbott, Abbvie)*
Hagen, Jennifer	*3B (Depuy Synthes)*
Haglin, Jack	*(n)*
Hahn, Jesse	*(n)*
Haidukewych, George	*1 (Depuy, Biomet); 4 (Orthopediatrics); 6 (Fellowship support synthes); 9 (Board member Hip Society, ICJR)*
Hak, David (Program Committee)	*3B (Globes, Acumed); 7 (Slack); 8 (J. Ortho Trauma; Orthopedics; European Journal of Orthopedics, Sports, and Trauma); 9 (International Section of Fracture Repair (ORS), Fragility Fracture Network)*
Hake, Mark	*4 (Medtronic); 6 (Zimmer Biomet)*
Hall, Jeremy	*(n)*
Haller, Justin	*(n)*
Halsey, David	*9 (AAOS)*
Hamood, Abdul	*(n)*
Handley, Robert	*2 (Faculty for Stryker Oxford Middle East Trauma Course. Content related to fractures but not ankle fractures); 5 (PI for White 4 hip study supported by X Bolt. Not related to current study); 9 (Immediate Past President Orthopaedic Trauma Society. Trustee British Orthopaedic Association)*
Hankins, Michael	*(n)*
Hanna, Philip	*(n)*
Hao, Jiandong	*(n)*
Haonga, Billy	*(n)*
Hardman, John	*(n)*
Hardwicke, Joseph	*(n)*

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Harris, Mitchel	*(n)*
Hart, Christopher	*(n)*
Hart, Dave	*(n)*
Hartley, Brandi	*(n)*
Harvey, Edward	*3C (Greybox Ltd); 4 (NXTSens); 6 (Institutional support- Johnson and Johnson); 7 (Canadian Journal of Surgery, Journal of Bone and Joint Surgery); 8 (Journal of Orthopaedic Trauma); 9 (Orthopaedic Trauma Association)*
Harvin, William	*3B (BLB Premiere Management LLC, GBS Premiere Management LLC, DBV Management Group LLC)*
Harwood, Paul	*2 (Zimmer Biomet, Depuy Synthes)*
Hasenboehler, Erik	*2 (DePuy Synthes Trauma); 3B (DePuy Synthes Trauma); 4 (Summit MedVenture); 5 (DePuy Synthes Trauma, Stryker Trauma)*
Haverlag, Robert	*(n)*
Haws, Brittany	*(n)*
Hayda, Roman	*2 (AONA, Synthes); 3C (Biointraface); 8 (reviewer: JOT, JBJS, JBJS Reviews, CORR); 9 (METRC, OTA, AAOS)*
Haydel, Christopher	*2 (Synthes)*
Hayes, Christopher	*(n)*
Hebert-Davies, Jonah	*(n)*
Heels-Ansdell, Diane	*(n)*
Heetveld, Martin	*(n)*
Heigle, Gregory	*(n)*
Heil, Koloman	*(n)*
Heinrich, Stephen	*(n)*
Helfet, David	*(n)*
Helgason, Benedikt	*(n)*
Henderson, Corey	*(n)*
Hendrickson, Sarah	*(n)*
Heng, Marilyn	*(n)*
Henley, M	*1 (Wolters Kluwer; Zimmer, Renovis); 3B (Zimmer); 3C (Karen Zupko and Associates); 4 (Renovis); 7 (Wolters Kluwer Health); 9 (AAOS)*
Henn III, Ralph	*(n)*
Hennessy, David	*(n)*
Henschel, Julia	*(n)*
Hesketh, Patrick	*(n)*
Heubner, J	*(n)*
Heyburn, Gary	*(n)*
Heyrani, Nasser	*(n)*
Hietbrink, Falco	*(n)*

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Higgins, Thomas	*1 (DePuy Synthes); 4 (Summit MedVentures, Orthogrid, NT nPhase)*
Hildebrand, Frank	*(n)*
Hildebrand, Kevin	*(n)*
Hill, Austin	*4 (Orthopedic Implant Company)*
Hiratzka, Shannon	*(n)*
Hirschfeld, Adam	*(n)*
Ho, Christine	*2 (Honorarium from Broadwater for instructor at 1st Pediatric Orthopaedic Surgical Techniques Course); 3A (Paid employment from Pedi-Ortho Health Corp); 7 (Royalties from Elsevier as author of chapters in Tachdjian's Pediatric Orthoapedics, 5th ed); 9 (Chair, OrthoKids Committee for POSNA)*
Ho, Steve	*(n)*
Hoekstra, Harm	*(n)*
Hoffmann, Jacob	*(n)*
Hogue, Matthew	*(n)*
Hollyer, Marcus	*(n)*
Hoogendoorn, Jochem	*(n)*
Horan, Annamarie	*6 (Co-founder/owner of Osteomics, LLC.)*
Horn, David	*7 (JayPee Publishing Co.)*
Horst, Klemens	*(n)*
Horwitz, Daniel	*1 (Zimmer Biomet, New Clip); 5 (DePuy Synthes research fellow support); 9 (AAOS Chair Trama content Committee, President FOT)*
Hotchkiss, Robert	*4 (Imagen Technologies); 7 (Elsevier)*
Hotchkiss, Thomas	*3A (I'm a co-founder of Imagen Technologies)*
Houdek, Matthew	*(n)*
Houseman, Bryan	*(n)*
Houwert, Roderick	*(n)*
Hovis, James	*(n)*
Howard, Anthony	*(n)*
Howe, Lindsay	*(n)*
Howenstein, Abby	*(n)*
Hsu, Joseph	*2 (Smith Nephew); 3B (Acumed)*
Hu, Gene	*(n)*
Huang, Yanjie	*(n)*
Hubbard, David	*2 (Depuy Synthes)*
Hubbard, Elizabeth	*(n)*
Huddleston, James	*2 (Exactech, Inc, Zimmer); 3B (Biomet, California Joint Replacement Registry, Exactech, Inc, Porosteon, Zimmer); 4 (Porosteon); 5 (American Knee Society, Biomet, Robert Wood Johnson Foundation); 7(Exactech, Inc); 8 (Journal of Arthroplasty); 9 (California Joint Replacement Registry, Hip Society, AAOS, American Association of Hip and Knee Surgeons, Knee Society)*
Hulick, Robert	*(n)*

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Hull, Brandon	*(n)*
HUMMER Investigators	*(n)*
Humphrey, Catherine	*(n)*
Hung, Ben	*(n)*
Huo, Jason	*(n)*
Hurwitz, Shepard	*6, 7 (Saunders/Mosby-Elsevier, SLACK Incorporated); 8 (Journal of Bone and Joint Surgery – American);*
Hustedt, Joshua	*(n)*
Hwang, John	*(n)*
Hydrick, Josie	*(n)*
Hymes, Robert	*3B (Stryker Orthopedics); 5 (Depuy Synthes)*
Hynes, Kelly	*(n)*
Ibrahim, Mazen	*(n)*
Ihn, Hansel	*(n)*
Ilyas, Asif	*1 (Globus); 2 (Depuy Synthes); 3B (Globus); 5 (Axogen); 7 (Jaypee Medical Publishers); 9 (Pennsylvania Orthopaedic Society)*
Infante, Anthony	*(n)*
Ingari, John	*(n)*
Inkpen, Kevin	*3B (AO Foundation grant)*
Ishii, Keisuke	*(n)*
Israel, Heidi	*(n)*
Jaarsma, Ruurd	*(n)*
Jackson, Lyle	*7 (EBSCO/Dynamed)*
Jackson, Phillipa	*(n)*
Jacobs, Cale	*(n)*
Jahangir, A	*4 (Carbofix); 7 (Springer); 9 (OTA, ACS COT)*
Jahed, Kiarash	*(n)*
Jaiswal, Praag	*(n)*
Jarman, Molly	*(n)*
Javedan, Houman	*(n)*
Jenkinson, Richard	*(n)*
Jeray, Kyle	*2 (Radius); 3B (ZimmerBiomet); 5 (Synthes,); 8 (Associate editor JOT); 9 (SCOA Board member, SEFS Board member, Chair Critical Issues Committee AOA, Chair membership committee OTA, Chair Own the Bone Steering Committee AOA)*
Jimenez, Matthew	*(n)*
Johal, Herman	*(n)*
Johnson, Joseph	*(n)*
Johnson, Louise	*(n)*
Johnson, Sam	*3A (Conventus Orthopaedics)*

Disclosure:
(n) = Respondent answered 'No' to all items indicating no conflicts; 1= Royalties from a company or supplier; 2= Speakers bureau/paid presentations for a company or supplier; 3A= Paid employee for a company or supplier; 3B= Paid consultant for a company or supplier; 3C= Unpaid consultant for a company or supplier; 4= Stock or stock options in a company or supplier; 5= Research support from a company or supplier as a PI; 6= Other financial or material support from a company or supplier; 7= Royalties, financial or material support from publishers; 8= Medical/orthopaedic publications editorial/governing board; 9= Board member/committee appointments for a society. *= Not available at time of printing. Refer to pages 463 - 465.

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Johnstone, Alan	*3C (Clearsurgical Ltd. SoftCell Medical Ltd); 4 (SoftCell Medical Ltd); 5 (Invibio. Zimmer Biomet); 6 (CarboFix); 9 (International Society for Fracture Repair. Orthopaedic Trauma Society)*
Jolissaint, Josef	*(n)*
Jones, Alan	*(n)*
Jones, Clifford	*3B (Stryker); 5 (METRC Johns Hopkins DOD, FAITH NIH); 7 (Lippincott); 9 (OTA BOD)*
Jones, Elena	*(n)*
Jones, LaRita	*(n)*
Joseph, David	*(n)*
Josephson, Anna	*(n)*
Joshi, Manjari	*(n)*
Ju, Derek	*(n)*
Judd, Kyle	*5 (DJO); 9 (AAOS Central Evaluation Committee)*
Jupiter, Jesse	*2 (DePuy, A Johnson & Johnson Company); 3B (Aptis Co, OHK); 3C (SynthesTrimed); 4 (OHK); 5 (AO Foundation); 6,7 (ElsevierThieme); 8 (J of Hand Surg amJ of Orthop trauma Techniques in Hand and Upper Extremity SurgeryHand, techniques in shoulder and elbow surgery); 9 (AAHS Board curriculum committee, American Shoulder and Elbow Surgeons, American Society for Surgery of the Hand);*
Kadakia, Rishin	*(n)*
Kagan, Ryland	*(n)*
Kahn, Mani	*(n)*
Kakazu, Rafael	*(n)*
Kanakaris, Nikolaos	*3B (Stryker as member of the European clinical advisory board; Zimmer Biomet as educational consultant; Depuy Synthes as consultant on new patella plating system); 3C (Smith and Nephew consultant for limited market release of implant); 7 (Springer Nature); 8 (Hard Tissue" and "Open Access Trauma" of Open Access Publishing London; "BioMed Research International" of Hindawi Publishing Corporation.); 9 (ESTROT)*
Kandemir, Utku	*2 (AONA, Stryker); 5 (Synthes, Biomet); 9 (OTA Education Committee)*
Kang, Jason	*(n)*
Kanlic, Enes	*(n)*
Kano, Daiji	*(n)*
Karam, Matthew	*4 (Mortise Medical LLC)*
Karr, Sean	*(n)*
Karunakar, Madhav	*(n)*
Kates, Stephen	*3B (Sage Publications, Editor of Journal); 5 (DePuy Synthes support for resident grant); 6 (DePuy Synthes- AO Foundation travel); 8 (Sage Publications); 9 (AO Foundation)*
Kavanagh, Michael	*(n)*
Kawaguchi, Alan	*(n)*
Keating, John	*(n)*
Keene, David	*(n)*
Kellam, James	*(n)*
Keller, Tyler	*(n)*

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Kelly, Meghan	*(n)*
Kelly, Michael	*(n)*
Kelly, Michael	*2 (Stryker); 3B (Stryker, Synthes); 9 (Orthopaedic Trauma Society (UK));*
Kempton, Laurence	*(n)*
Kerkhoffs, Gino	*(n)*
Ketz, John	*(n)*
Khan, Tanvir	*(n)*
Khechen, Benjamin	*(n)*
Khoury, Amal	*(n)*
Kim, Beom Soo	*(n)*
Kim, Chang-Yeon	*(n)*
Kim, Jin-Kak	*(n)*
Kim, Ji-Wan	*(n)*
kim, kwangkyoun	*(n)*
Kimmerling, K	*3A (NuTech Medical, Inc.)*
Kiner, Dirk	*3B (Globus Medical)*
Kistler, Brian	*2 (Smith & Nephew)*
Klaucke, Jonathan	*(n)*
Klaue, Kaj	*3C (BIEDERMANN Motech)*
Kleimeyer, John	*(n)*
Kleiner, Justin	*(n)*
Kleweno, Conor	*(n)*
Knio, Ziyad	*(n)*
Ko, S	*(n)*
Koerner, John	*8 (Clinical Spine Surgery); 3A, 4 (Norvartis); 5 (Medtronic); 6 (Jaypee Publishing); 7(Creosso, Jaypee Publishing);*
Koerner, Michael	*(n)*
Koh, Justin	*(n)*
Kojima, Kodi	*2 (Merck Brasil); 3B (Taimin Brasil); 8 (AOTrauma International – Chairperson elected); 9 (President Brazilian Society of Orthopedic Trauma)*
Konda, Sanjit	*(n)*
Kong, Hoa	*(n)*
Korley, Robert	*(n)*
Kottmeier, Stephen (Program Committee)	*(n)*
Koval, Kenneth	*1 (Zimmer Biomet, Orthofix, Lima, Newclip, AOS); 2 (Stryker, Citieffe)*
Krag, Martin	*7 (DePuy, A Johnson & Johnson Company); 3B, 5 (Spineology)*
Kraus, Virginia Byers	*3b (AbbVie, Flexion Therapeutics, Parexel, Pfizer); 5 (Unity Biotechnology)*
Krause, Peter	*(n)*

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Kreder, Hans	*3B (My son is a trauma consultant for Depuy Synthes); 6 (Unrestricted research grants to institution from Zimmer Biomet, Stryker and Depuy Synthes); 7 (Elsevier: Royalties for Textbook)*
Krettek, Christian	*2 (Synthes); 5 (Ellipse Technologies Inc, Nuvasive); 6 (Stryker); 7 (Saunders/Mosby-Elsevier, Springer, Synthes); 8 (Springer); 9 (MedUpdate)*
Krijnen, Pieta	*(n)*
Kroeger, Inga	*(n)*
Krum, Nicole	*(n)*
Krupko, Thomas	*(n)*
Kubiak, Erik	*3B (DJO Global); 4 (Conextions Medical, Orthogrid); 5 (Department of Defense)*
Kubik, Jeremy	*(n)*
Kugelman, David	*(n)*
Kuhl, Mitchell	*3B (Stryker)*
Kuhn, Kevin	*(n)*
Kumar, Gunasekaran	*2 (Smith and Nephew Trauma)*
Kumaravel, Manickam	*(n)*
Kumm, Todd	*(n)*
Kuripla, Casey	*(n)*
Kurylo, John	*(n)*
Kwek, Ernest	*(n)*
Kwon, John	*(n)*
Kyle, Richard	*1 (Smith/Nephew, Zimmer)*
Lachman, James	*3B (Depuy Synthes)*
Lafferty, Paul	*(n)*
Lall, Ranjit	*(n)*
Lamb, Sallie	*(n)*
Lamer, Stephanie	*(n)*
Lane, Joseph	*3B (Bone Therapeutics, Graftys, Kuros, Turemo, BiologicsMD, CollPlant); 4 (CollPlant); 5 (Novartis , NIH Co-PI, Merck); 9 (AOA "Own The Bone")*
Langford, Joshua	*3B (Stryker); 4 (Core Orthopaedics); 7 (Advanced Orhopaedic Solutions); 8 (Journal of Orthopaedic Trauma)*
Lansink, Koen	*(n)*
Laratta, Joseph	*(n)*
Large, Thomas	*4 (Orthopaedic Implant Company)*
Lau, Brian	*5 (GE Healthcare)*
Lawendy, Abdel-Rahman	*(n)*
Leach, Jonathan	*(n)*
Learned, James	*(n)*
LeBrun, Christopher	*(n)*

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Ledet, Eric	*4 (inSense Medical; I/O Surgical)*
	(n)
Leduc, Stephane	*2 (Stryker); 3B (Stryker); 5,(Amgen Co, DePuy, A Johnson & Johnson Company, Smith & Nephew); 6 (Amgen Co, Eli Lilly, Norvartis, Sanofi-Aventis, Stryker, Synthes)*
Lee, Adam	*(n)*
Lee, Andrew	*(n)*
Lee, Jackson	*2 (DePuy, A Johnson & Johnson Company)*
Lee, Mark	*3B (Globus, Depuy Synthes); 9 (OTA Public Relations Committee)*
Lee, Moses	*(n)*
Lee, Thay	*1 (Conmed; Smith and Nephew; Stryker); 3B (Arthrex); 4 (Coracoid Solutions; Subchondral Solutions); 5 (Arthrex); 8 (J Shoulder and Elbow Surg; Am J of Orthopedics; Clinics in Orthopaedic Surgery)*
Leenen, Loek	*(n)*
Lefaivre, K	*5 (Zimmer); 6 (Synths, AONA research support); 8 (JOT Editorial Board); 9 (COA Fellowship Committee chair, OTA Research Committee)*
Lehman, Ronald	*2 (Medtronic, Stryker, DePuy Synthes Spine); 3B (Medtronic); 7 (Lippincott, Williams, and Wilkins); 8 (The Spine Journal, Spine Deformity)*
Leighton, Ross	*1 (Zimmer); 2 (Bioventis, Smith and Nephew, Synthes, Johnson and Johnson); 3B (Bioventius, Smith and nephew,); 5 (Johnson and Johnson, Smith and Nephew); 9 (Orthopedic Trauma Association, Board of Councillors AAOS)*
Leucht, Philipp	*2 (Zimmer Biomet); 3B (Ankara Regenerative Therapeutics); 4 (Ankasa Regenerative Therapeutics); 9 (AAOS Biological Implants Committee)*
Leung, Frankie	*(n)*
Levack, Ashley	*(n)*
Levine, Ari	*(n)*
Lewis, Angus	*(n)*
Li, Jiao Jiao	*3A (Osseointegration International Pty Ltd); 8 (Tissue Engineering, Parts A, B, & C)*
Li, Lulu	*(n)*
Li, Yi-Ju	*(n)*
Li, Ying	*9 (Pediatric Orthopaedic Society of North America Reserch Committee member, Scoliosis Research Society Safety & Value Committee member)*
Lichstein, Paul	*(n)*
Liebergall, Meir	*(n)*
Lieshout, Esther	*8 (BMC Musculoskeletal Disorders); 9 (Osteosynthesis and Trauma Care Foundation)*
Liew, Allan	*4 (Johnson & Johnson)*
Liew, Susan	*(n)*
Liggins, Fergus	*(n)*
Lin, Carol	*(n)*
Lin, James	*(n)*
Lin, Kenneth	*(n)*

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Lindsey, Robert	*3A (Imagen Technologies); 4 (Imagen Technologies)*
Lindvall, Eric	*3B (Renovis)*
Lipof, Jason	*(n)*
Liporace, Frank	*2 (Biomet, Stryker, Synthes) 3B (Biomet, Medtronic, Stryker, Synthes); 3C (AO); 7 (Biomet)*
Liras, Ioannis	*(n)*
Little, Kevin	*9 (American Association for Hand Surgery, American Society for Surgery of the Hand, Pediatric Orthopaedic Society of North America)*
Little, Milton	*(n)*
Littlechild, Joseph	*(n)*
Lo, Yungtai	*(n)*
Lobo, Dileep	*5 (BBraun); 8 (Clinical Nutrition and the World Journal of Surgery)*
Lorich, Dean	*(n)*
Lott, Ariana	*(n)*
Lowe, Jason	*3B (Stryker, Acumed)*
Lu, William	*3A (Osseointegration International Pty Ltd)*
Lucas, Paul	*(n)*
Ludwig, Steven	*1 (DePuy, A Johnson & Johnson Company, Thieme, QMP); 2 (DePuy, A Johnson & Johnson Company, Synthes); 3B (K2Medical, Globus Medical, Synthes, DePuy, A Johnson & Johnson Company); 4 (ASIP, ISD); 5 (Globus Medical, K2M Spine, Pacira, OMEGA, AO Spine North America Spine Fellowship Support); 6 (Thieme, QMP); 8 (Journal of Spinal Disorders and Techniques); 9 (Smiss, Cervical Spine Research Society, American Board of Orthopaedic Surgery, Inc, American Orthopaedic Association)*
Luly, Jason	*(n)*
Lunardini, David	*(n)*
Lund, Erik	*(n)*
Lundy, Douglas	*(n)*
Lyon, Thomas	*(n)*
Ma, Zhuo	*(n)*
MacCormick, Lauren	*(n)*
MacDonald, Ashlee	*(n)*
MacDonald, Deborah	*(n)*
Maceroli, Michael	*(n)*
MacKenzie, Ellen	*(n)*
Mackenzie, Samuel	*(n)*
MacLeod, Mark	*(n)*
Madey, Steven	*1 (Zimmer, J&J)*
Madsen, JE	*(n)*
Mahabier, Kiran	*(n)*
Major Extremity Trauma Research Consortium (METRC)	*(n)*

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Makhni, Melvin	*(n)*
Maletz, Frank	*(Not needed for resident's course)*
Maloney, William	*1 (zimmer – knee implants stryker – hip and knee implants); 9 (American Academy of Orthopaedic Surgeons)*
Mamczak, Christiaan	*2 (Smith & Nephew, AONA); 3B (Smith & Nephew); 7 (Springer); 9 (OTA, AOAO)*
Mamun, A	*(n)*
Manson, Theodore	*(n)*
Mansour, Alfred	*9 (POSNA – E-Editorial Committee Member; AAOS – Pediatric Evaluation Committee member)*
Mansour, J	*3B (SEAL); 3C (Carbofix); 4 (Carbofix);*
Marcantonio, Andrew	*(n)*
Marchand, Lucas	*(n)*
Marecek, Geoffrey	*3B (Globus Medical, ETEX); 9 (AAOS, OTA)*
Marinos, Dimitrius	*(n)*
Markel, David	*3A (The CORE Institute); 3B (Stryker Orthopedics, Halyard Health); 4 (The CORE Institute); 5 (Stryker, OREF); 9 (Michigan Orthopaedic Society Board member)*
Marlowe, Heather	*(n)*
Marsh, J Lawrence	*(n)*
Marshall, Lynn	*(n)*
Marston, Scott	*(n)*
Martin, Benjamin	*9 (History and Archives Committee, POSNA)*
Martin, C. Ryan	*(n)*
Mascarenhas, Daniel	*(n)*
Mashru, Rakesh	*(n)*
Masters, James	*(n)*
Matityahu, Amir	*2 (DePuy-Synthes, A Johnson & Johnson Company); 3B (Acumed, LLC); 4(Anthem Orthopedics, LLC, Episode Solutions, LLC, EPIX Orthopaedics, Inc, PDP Holdings, LLC); 9 (AO Foundation, Orthopaedic Trauma Association)*
Matsushita, Takashi	*3B (HOYA Technosurgical); 9 (Fragility Fracture Networl Japan, Bone and Joint Japan)*
Matuszewski, Paul	*(n)*
Mauffrey, Cyril	*3C (Stryker); 5 (Carbofix, Stryker, Accumed, Depuy/Synthes); 7 (Elsevier, Springer, Slack); 8 (Editorial board Injury, European Journal of Orthopedics and International Orthopedics); 9 (ISFR board of director)*
Maurer, James	*(n)*
Maxson, Benjamin	*(n)*
Mayo, Keith	*2,7 (Synthes)*
Mayo, Samuel	*3A (Broad Institute of MIT and Harvard:Employee)*
McAllister, Scott	*(n)*
McAndrew, Christopher	*2 (AO Trauma North America); 5 (Synthes, Smith Nephew, NIH);*
McAndrew, Mark	*9 (ACS/COT, BOD SOMOS)*

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McArdle, Michael	*(n)*
McCalla, Daren	*(n)*
McCann, Conor	*(n)*
McCarroll, Tyler	*(n)*
McCarthy, Moira	*(n)*
McCormack, Robert	*(n)*
McCreary, Dylan	*(n)*
McCunniff, Peter	*(n)*
McDonald, Sinead	*(n)*
McGarry, Michelle	*4 (Subchondral Solutions)*
McGonagle, Dennis	*(n)*
McGowan, Brian	*(n)*
McKay, Jennifer	*(n)*
McKee, Michael (Program Committee)	*1 (Stryker); 3B (Zimmer, Stryker, ITS, Acumed,); 7 (LWW, Elsevier); 8 (JOT, Orthopaedics Today); 9 (OTA)*
McKinley, Todd	*1 (Innomed); 3B (Bioventus)*
McLaurin, Toni	*3B (Synthes); 6 (DePuy Orthopaedics; Smith & Nephew; Stryker; Synthes)*
McQueen, Margaret	*7 (Wolters Kluwer)*
McTague, Michael	*(n)*
McWilliam-Ross, Kindra	*(n)*
Mears, Simon	*8 (Geriatric Orthopaedic Surgery and Rehabilitation); 9 (International Geriatric Fracture Society)*
Mehle, Susan	*(n)*
Mehta, Samir	*2 (Bioventus); 3B (Smith & Nephew, Synthes); 5 (Synthes); 7 (Elsevier); 8 (Current Orthopaedic Practice); 9 (PA Ortho Society, AOPOC, AOTNA)*
Meijer, Diederik	*(n)*
Meinberg, Eric	*9 (AOTrauma North America, Northern California Orthopaedic Society); 8 (Springer)*
Menard, Jeremie	*(n)*
Mendelson, Daniel	*3C (PharmAdva, LLC); 4 (TouchStream Solutions/PointClickCare); 8 (Geriatric Orthopaedic Surgery & Rehabilitation); 9 (International Geriatric Fracture Society, American Geriatrics Society)*
Mener, Amanda	*(n)*
Merk, Bradley	*3B (Stryker, Acumed)*
Merle, Geraldine	*(n)*
Mesfin, Addisu	*5 (Globus); 9 (SRS, AAOS, NASS, CSRS, J Robert Gladden Society)*
Messner, Juergen	*(n)*
Metzger, Cameron	*(n)*
Meyer, Darlene (OTA Staff)	*(n)*
Michelov, Yehuda	*(n)*

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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 463 - 465.

Miclau, Theodore	*(n)*
Middleton, Scott	*(n)*
Mignemi, Megan	*(n)*
Miles, Daniel	*(n)*
Miller, Anna	*8 (Journal of Orthopaedic Trauma, Journal of Bone and Joint Surgery); 9 (American College of Surgeons, American Academy of Orthopaedic Surgeons, Orthopaedic Trauma Association)*
Miller, Ashley	*(n)*
Miller, Mark	*(n)*
Miller, Matthew	*(n)*
Min, W	*2 (Acumed; Citieffe); 3B (Acumed; Citieffe); 3C (CarboFix); 4 (CarboFix); 8 (Journal of Orthopaedic Surgery and Research; Trauma Cases and Reviews)*
Ming, Bryan	*(n)*
Mir, Hassan	*3B (Smith & Nephew, Depuy-Synthes, Pharmacom Group); 8 (OTA Newsletter Editor, JOT Associate Editor); 9 (AAOS Diversity Advisory Board, AOA Leadership/Fellowships Committee, OTA PR Committee, FOT Nominating Committee)*
Mirarchi, Adam	*(n)*
Mirza, Amer	*(n)*
Mistry, Dipesh	*(n)*
Mitchell, Phillip	*(n)*
Mitchell, Sean	*(n)*
Mitchell, Thomas	*(n)*
Moghadamian, Eric	*2 (Zimmer Biomet); 3B (Depuy Synthes)*
Mohamadi, Amin	*(n)*
Mohtadi, Nicholas	*8 (American Journal of Sports Medicine, Clinical Journal of Sport Medicine, Journal of Sportorthopädie-Sporttraumatologie, Bone and Joint 360Physician and Sports Medicine); 9 (Canadian Academy of Sport and Exercise Medicine, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine)*
Moller, Emilia	*5 (Depuy)*
Moloney, Gele	*(n)*
Monsey, Robert	*(n)*
Montalvo, Ryan	*(n)*
Moon, Andrew	*(n)*
Moon, Charles	*3B (Stryker); 5 (Bone Support)*
Moon, Gi-Ho	*(n)*
Mooney, Robert	*(n)*
Moore, Dustin	*(n)*
Moore, Ernest	*5 (Haemonetics and TEM Systems)*
Moore, Sharon (OTA Staff)	*(n)*
Moore, Timothy	*8 (Spine, JAAOS); 9 (CSRS, LSRS, AAOS)*
Morales, Pablo	*(n)*

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Moran, Christopher	*(n)*
Moretti, Luca	*(n)*
Morgan, Steven	*4 (Johnson & Johnson); 7 (SLACK Incorporated); 8 (Journal of Orthopaedic Trauma); 9 (Orthopaedic Trauma Association)*
Morling, Joanne	*(n)*
Mormino, Matthew	*9 (Mid America Orthopaedic Association)*
Morshed, Saam	*(n)*
Morton, Paul	*(n)*
Mosheiff, Rami	*(n)*
Mostafavi, Hamid	*(n)*
Mounasamy, Varatharaj	*(n)*
Mudaliar, Nithya	*(n)*
Muessig, Janina	*(n)*
Mulders, Marjolein	*(n)*
Mullis, Brian	*2 (Zimmer Biomet; Smith & Nephew); 3B (Zimmer Biomet); 5 (Zimmer Biomet); 9 (OTA Education Committee)*
Munley, Jennifer	*(n)*
Munro, Mark	*3B (MAXX orthopedics)*
Munz, John	*(n)*
Murphree, Jefferson	*(n)*
Murphy, Jordan	*(n)*
Murr, Kevin	*(n)*
Murray, Gordon	*(n)*
Murray, Iain	*8 (Bone and Joint Research); 9 (British Orthopaedic Research Society)*
Myeroff, Chad	*(n)*
Naim, MD, Maryam	*(n)*
Nally, Francisco	*(n)*
Nam, Diane	*(n)*
Nance, Michael	*(n)*
Narayanan, Unni	*3C (AO Foundation); 8 (Journal of Children's Orthopaedics); 9 (Pediatric Orthopaedic Society of North America, American Academy for Cerebral Palsy and Developmental Medicine, International Hip Dysplasia Institute)*
Nascone, Jason	*2 (Smith & Nphew, Synthes); 3B (IMDS, Smith & Nephew); 7 (IMDS, Synthes); 8 (Journal of Orthopaedic Trauma); 9 (AONA, Orthopaedic Trauma Association)*
Nathens, Avery	*(n)*
Natoli, Roman	*(n)*
Nault, Marie-lyne	*6 (Johnson & Johnson, Smith & Nephew, Stryker, Wright Medical Technology, Inc)*
Nauth, Aaron	*2 (Stryker Canada); 5 (Stryker, Zimmer, Synthes, Capital Sports Entertainment); 9 (OTA Basic Science Committee)*

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Nazarian, Ara	*(n)*
Neibart, Shane	*(n)*
Nellestein, Andrew	*(n)*
Nelms, Nathaniel	*8 (Arthroplasty Today)*
Nelson, Richard	*(n)*
Nepola, James	*1 (Zimmer Biomet); 3C (Zimmer Biomet); 8 (American Journal of Orthopedics; Journal of Shoulder and Elbow Surgery; Orthopedic Journal of Sports Medicine;Wolters Kluwer Health - Lippincott Williams & Wilkins); 9 (American Orthopedic Association (Committee))*
Neufeld, Michael	*(n)*
Newcomb, Anna	*(n)*
Nguyen, Mai	*(n)*
Nicholson, Jamie	*(n)*
Nijs, Stefaan	*(n)*
Noble, Tyler	*(n)*
Noblet, Tim	*(n)*
Nomides, Riika	*(n)*
Nomides, Riikka	*(n)*
Noor, Arwin	*(n)*
Nork, Sean	*2 (Depuy Synthes); 3B (Depuy Synthes)*
Norris, Brent	*3A (Norris Surgical, LLC); 3B (Depuy-Synthes, Acumed); 6 (AONA Fellowship Grant); 9 (OTA, Committee Member)*
Norris, Russell	*(n)*
Nowak, Lauren	*(n)*
Nowotarski, Peter	*2, 3B (Synthes)*
Nunes Cardozo, Menno	*(n)*
Nunley, Ryan	*3B (Biocomposites, Cardinal Health, DePuy, A Johnson & Johnson Company, Halyard, Medical Compression System Inc, Medtronic, Smith & Nephew); 5(DePuy, A Johnson & Johnson Company, Biomet, Smith & Nephew, Stryker, Medical Compression Systems, Inc.); 9 (American Association of Hip and Knee Surgeons, Hip Society, Mid-America Orthopaedic Association, Program Committee, Missouri State Orthopaedic Association, Southern Orthopaedic Association, Missouri Councilor, and President Elect, The Knee Society, Education Committee)*
Nwachuku, Chinenye	*3A (Pfizer); 3B (Depuy/Synthes)*
Nwachukwu, Benedict	*(n)*
Obirieze, Augustine	*(n)*
Obremskey, William	*9 (Southeastern Fracture Society Board)*
O'Brien, P	*2 (Zimmer Biomet, Stryker); 5 (Depuy Synthes, Zimmer)*
O'Connell, Rachel (OTA Staff)	*(n)*
O'Connor, Daniel	*3B (Nimbic, Inc.)*
O'Daly, Brendan	*(n)*

Disclosure:
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O'Gara, Brian	*(n)*
Oh, Chang-Wug	*(n)*
Oh, Jong-Keon	*(n)*
O'Halloran, Kevin	*(n)*
O'Hara, Lyndsay	*(n)*
O'Hara, Nathan	*(n)*
Olinger, Catherine	*(n)*
Ollivere, Benjamin	*5 (Smith & Nephew); 6 7, 8 (Journal of Bone and Joint Surgery – British); 9 (AO UK)*
Olson, Steven	*(n)*
O'Neill, David	*(n)*
Ordonio, Katherine	*(n)*
Orman, Sebastian	*(n)*
Ortega, Gilbert (Program Committee)	*2 (Smith and Nephew; Carbofix); 3B (Smith and Nephew; Carbofix); 4 (Carbofix); 9 (Orthopaedic Trauma Association-Committee and Membership Member)*
Osei, Daniel	*9 (American Society for Surgery of the Hand)*
Osgood, Greg	*3B (Depuy Synthes; Stryker; Globus); 5 (Siemens; Carestream); 8 (Journal of Orthopaedic Trauma); 9 (Foundation for Orthopaedic Trauma)*
Oshinson, Elizabeth (OTA Staff)	*(n)*
Ostrum, Robert	*(n)*
O'Toole, Robert	*2 (Coorstek); 3B (Imagen, Smith & Nephew); 4 (Imagen); 5 (Stryker, Synthes); 7 (Coorstek); 9 (Orthopaedic Trauma Association)*
Otsuka, Norman	*(n)*
OUTLET Team, METRC	*(n)*
Ovre, S	*(n)*
Owens, Johnny	*3B, 7 (Delfi Medical Innovations, Inc)*
Paetzold, Robert	*(n)*
Pallister, Ian	*(n)*
Panchbhavi, Vinod	*2 (Stryker); 6,7 (Wolters Kluwer Health - Lippincott Williams & Wilkins: Publishing); 8 (Foot and Ankle InternationalTechniques in Foot & Ankle Surgery, Orthopedia.com); 9 (AAOS, American Orthopaedic Foot and Ankle Society)*
Pant, Bhaskar	*(n)*
Panteli, Michalis	*(n)*
Panzica, Martin	*(n)*
Papadimitriou, Evangelia	*(n)*
Pape, Hans-Christoph	*(n)*
Papp, Steven	*(n)*
Park, Kichul	*(n)*
Park, Nathan	*(n)*
Park, Young-Chang	*(n)*

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Parks, Christopher	*(n)*
Parry, Joshua	*(n)*
Parsons, Luke	*(n)*
Parsons, Nick	*(n)*
Parsons, Scott	*(n)*
Pasha, Arham	*(n)*
Patel, Neel	*(n)*
Patel, Neeraj	*(n)*
Patel, Parth	*(n)*
Patel, Shaan	*(n)*
Paterson, Paul	*1 (Integra); 2 (Lima, Conventus, Skeletal Dynamics); 4 (Conventus Ortho); 5 (Conventus Ortho, Lima)*
Patterson, Brendan	*(n)*
Patterson, Joseph	*(n)*
Pavlesen, Sonja	*(n)*
Paxton, Liz	*(n)*
Pechon, Pierre	*(n)*
Pena, Fernando	*(n)*
Penn-Barwell, Jowan	*(n)*
Pensy, Raymond	*3B (Globus Medical); 7 (Springer)*
Perdue, Aaron	*3B (Zimmer, Globus)*
Perdue, Paul	*(n)*
Perera, Namal	*(n)*
Perez, Edward	*2 (Smith & Nephew); 3B (Cardinal Health)*
Peterson, David	*(n)*
Petrisor, Brad	*2 (Stryker); 5 (Zimmer); 6 (Pfizer, Stryker)*
Pfeifer, Roman	*(n)*
Phieffer, Laura	*(n)*
Phillips, Frank	*3B (Nuvasive); 4 (Mainstay, Nuvasive, PearDiver, Provident, SI Bone, Spinal Kinetics, Theracell, Vertera, Vital 5); 7(DePuy, A Johnson & Johnson Company, Medtronic, Nuvasive, Stryker); 8 (Int. Spine Journal); 9 (Cervical Spine Research Society, ISASS Society of Minimally Invasive Spine Surgery)*
Pickering, Greg	*(n)*
Pieracci, Fredric	*(n)*
Pincus, Daniel	*(n)*
Pipitone, Paul	*(n)*
Plowman, Brad	*(n)*
Plumarom, Yanin	*(n)*
Poka, Attila	*2 (Stryker); 3A (Connection Medical Inc);*

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Pollak, Andrew	*1 (Zimmer, Smith-Nephew, Globus); 7 (AAOS); 9 (National Trauma Institute)*
Pollock, Frederic	*(n)*
Potter, Benjamin	*3C (Zimmer Biomet); 8 (Deputy Editor, CORR; Associate Editor, J Ortho Trauma); 9 (1st Vice President, Society of Military Orthopaedic Surgeons)*
Potter, David	*(n)*
Potter, Jeffrey	*(n)*
Pountos, Ippokratis	*(n)*
Powell, James	*(n)*
Powell-Bowns, Matilda	*(n)*
Prabhakar, Pooja	*(n)*
Pradhan, Pallab	*(n)*
Prasarn, Mark	*2 (Eli Lilly, Nuvasive, Stryker); 3B (Stryker)*
Prayson, Michael	*3B (Bioventus); 8 (Journal of Orthopaedic Trauma); 9 (Board member for Wright State Physicians, Inc; Fellowship Committee member for The Orthopaedic Trauma Association)*
Prayson, Nicholas	*(n)*
PRIORITI-MTF Team, METRC	*(n)*
Pugh, Kevin	*2 (Smith Nephew, Medtronic, AO); 3B (Synthes, Smith Nephew); 8 (Journal of Orthopaedic Trauma)*
Pugley, Andrew	*1 (Nuvasive, Stryker, DePuy, Medtronic); 4 (Nuvasive, Vertera, Expanding Orthopaedics, SI Bone, Spinal Kinetics, Pearl Diver, Theracell, Vital 5); 7 (Elsevier); 8 (Int Spine Journal); 9 (ISASS, SMISS, SOLAS)*
Pull Ter Gunne, Albert	*3B (Synthes)*
Putnam, Sara	*(n)*
Qatu, Abdullah	*(n)*
Qiao, Zhi	*(n)*
Quade, Jonathan	*(n)*
Quatman, Carmen	*(n)*
Qudsi, Rameez	*3A (OrthoBullets reviewer and contributor);*
Quinnan, Stephen	*3B (Smith & Nephew, Depuy Synthes, Globus Medical); 5 (Depuy Synthes); 9 (Florida Orthopaedic Society)*
Quispe, Juan	*(n)*
Rahbar, Ellie	*(n)*
Rahme, Elham	*(n)*
Rajaee, Sean	*(n)*
Ralston, Stuart	*3B (Novartis); 5 (Eli Lilly, Amgen, Abbvie, UCB); 7 (Elsevier); 8 (Editor, Calcified Tissue International)*
Ramey, James	*3A (Eli Lilly); 4 (Eli Lilly)*
Ramirez-GarciaLuna, Jose	*(n)*
Ramnaraign, David	*(n)*
Ramo, Brandon	*7 (author royalties for Tachdijan's Operative- Saunders Elsevier)*

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Ramoutar, Darryl	*(n)*
Ramsey, Duncan	*(n)*
Rane, Ajinkya	*(n)*
Rascoe, Alexander	*(n)*
Ratheal, Ian	*(n)*
Ravi, Bheeshma	*(n)*
Ray, Robbie	*2 (Synthes: paid to present a generic presentation on the use of memory staples in foot and ankle surgery to the Synthes Australia sales force)*
Reahl, Bradley	*(n)*
Reams, Megan	*(n)*
Reddix, Robert	*3B (Orthofix)*
Reddy, Ravinder	*(n)*
Reed, Lori	*3B (SMV Scientific); 4 (SMV Scientific); 9 (OTA)*
Reed, Mike	*5 (Stryker supported this project financially contracting with my employing organisation (UK National Health Service). I may receive some fees for trial management from my employing organisation.)*
Refaat, Motasem	*(n)*
Rege, Rahul	*(n)*
Rehman, Saqib	*1 (Jaypee Medical Publishing); 2 (Depuy synthes); 9 (Orthopaedic Trauma Association, Foundation for Orthopaedic Trauma)*
Reid, J Spence	*2 (Smith & Nephew); 3B (Synthes); 5 (Synthes, Zimmer); 8 (Clinical Orthopaedics and Related Research, Journal of Orthopaedics and Traumatology); 9 (Limb Lengthening Research Society)*
Reider, Lisa	*(n)*
Reilly, Mark	*3B (Stryker Orthopaedics); 9 (Trustee, AO Foundation)*
Reilly, Rachel	*9 (OTA Committee Member)*
Reindl, Rudolf	*5 (Synthes)*
Reisman, William	*(n)*
Ren, Weiping	*(n)*
Renard, Regis	*3B (Medtronic Inc; Acumed Inc; Depuy Synthes Inc)*
Renninger, Christopher	*4 (KERX)*
Replogle, William	*(n)*
Reul, Maike	*(n)*
Ricart, Pedro	*(n)*
Ricci, William	*1 (Smith&Nephew, MicroPort); 3B (Smith&Nephew); 6 (Impress Medical, LLC, McGinley Orthopaedics, Primo Medical LLC); 7 (Wolters-Kluwer); 8 (JOT); 9 (OTA)*
Riccio, Anthony	*2 (DePuy Synthes); 7 (Elsevier)*
Richter, Peter	*(n)*
Ring, David	*1 (Skeletal Dynamics; Wright Medical); 8 (Deputy Editor for Journal of Orthopaedic Trauma; Deputy Editor, Clinical Orthopaedics and Related Research)*
Ringburg, Akkie	*(n)*

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Ringenbach, Kathleen	*(n)*
Rivera, Jessica	*(n)*
Roa, Kristoffer	*(n)*
Roach, Mary Jo	*(n)*
Roberts, Aaron	*(n)*
Roberts, Jason	*(n)*
Robertson, Christine	*(n)*
Robinette, J. Patton	*(n)*
Robinson, C.M.	*2 (Acumed, LLC); 3B (Acumed, LLC)*
Rocca, Michael	*(n)*
Rocha, Joao	*(n)*
Rodriguez, Aryelly	*(n)*
Roger, Douglas	*1 (Greatbatch Medical); 3B (Stryker)*
Rogmark, Cecilia	*(n)*
Rollins, Katie	*(n)*
Romeo, Jamie	*(n)*
Romeo, Nicholas	*(n)*
Rosales, Rich	*(n)*
Rose, Thomas	*(n)*
Rosenwasser, Melvin	*2 (Stryker, Zimmer); 3B (Stryker); 4 (CoNexions, Radicle Orthopedics); 9 (Foundation for Orthopedic Trauma)*
	(n)
Rosner, Bernard	*(n)*
Ross, Keir	*(n)*
Rossiter, Nigel	*2 (Heraeus Palacademy); 3B (Sectra); 6 (DePuySynthes); 9 (Orthopaedic Trauma Society, OrthoISIS medical indemnity, Primary Trauma Care Foundation, National Institute of Clinical Excellence)*
Rothberg, David	*(n)*
Rothwell, Luke	*(n)*
Routt, Milton	*2 (AO, Zimmer, Stryker, Ziehm); 9 (WOA Board)*
Row, Elliot	*(n)*
Roy, Krishnendu	*(n)*
Rubinger, Luc	*(n)*
Rudloff, Matthew	*1 (Elsevier); 2 (Smith & Nephew)*
Runner, Robert	*(n)*
Russell, George	*4 (SMV, Zimmer)*
Russell, Thomas	*1 (Smith Nephew); 2 (ZimmerBiomet)*
Ruzbarsky, Joseph	*(n)*

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Ryan, Scott	*2 (Smith and Nephew); 3B (Globus)*
Sacksteder, Nicholas	*(n)*
Sadasivan, Kalia	*(n)*
Sadeghi, Cameron	*(n)*
Sagi, H Claude	*1 (Stryker, USA); 3B (Stryker, USA); 5 (Stryker, USA); 8 (Journal of Orthopedic Trauma Editorial Board); 9 (American College of Surgeons, Committee on Trauma)*
Saifi, Comron	*3B (Vertera); 4 (Vertera)*
Sajobi, Tolulope	*(n)*
Saleh, Anas	*(n)*
Saleh, Hesham	*(n)*
Salentijn, Dorien	*(n)*
Salo, Paul	*(n)*
Samanta, Damayanti	*(n)*
Samoylova, Mariya	*(n)*
Samtani, Rahul	*(n)*
Sanchez, Hugo	*(n)*
Sancineto, Carlos	*2 (Speaker in a Depuy-Synthes Course)*
Sanders, David (Program Committee)	*3B (Smith and Nephew Richards, Stryker Canada); 5 (Arthrex,); 8 (Journal of Orthopaedic Trauma)*
Sanders, Drew	*(n)*
Sanders, Roy	*2 (Biomet, Smith & Nephew, Stryker, Zimmer); 3B (Smith & Nephew, Stryker, Zimmer); 5 (Health and Human Services, Medtronic, National Institutes of Health (NIAMS & NICHD), Smith & Nephew, Stryker,METRC (DOD), OTA); 7 (Biomet, CONMED Linvatec, Journal of Orthopaedic Trauma, Smith & Nephew, Stryker, Zimmer); 8 (Journal of Orthopaedic Trauma, Orthopedics Today); 9 (Orthopaedic Trauma Association)*
Sandifer, Phillip	*(n)*
Sangeorzan, Bruce	*9 (American Orthopaedic Foot and Ankle Society, Journal of Bone and Joint Surgery – American)*
Santoni, Brandon	*(n)*
Sarker, Minhaz	*(n)*
Sathy, Ashoke	*(n)*
Satpathy, Jibanananda	*(n)*
Saxena, Sharul	*(n)*
Sayegh, Michael	*(n)*
Scammell, Brigitte	*(n)*
Scharfstein, Daniel	*2 (GlaxoSmithKline); 3B (Actavis, Asubio, Bausch+Lomb, Bristol-Myers Squibb, Cephalon, Daiichi Sankyo, DePuy, A Johnson & Johnson Company; Ethicon, Forest Laboratories, Helsinn, InVivo Therapeutics, Johnson & Johnson, Luitpold, MELA Sciences, Merck, Norvartis, Otsuka Pharmaceuticals, Pfizer, Teva); 4 (Abbott, Abbvie, Medtronic, Express Scripts, Johnson & Johnson, Merck, Pfizer, Sanofi-Aventis, Tonix Pharmaceuticals)*
Schemitsch, Christine	*1 (Stryker); 3B (Stryker, Smith & Nephew, Amgen, Sanofi, Pendopharm, Acumed); 6 (ITS); 7 (Elsevier); 8 (J Orthopaedic Trauma); 9 (OTA, Hip Society, COA)*

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Schemitsch, Emil	*1 (Stryker); 3B (Stryker, Smith&Nephew, Amgen, Sanofi, Pendopharm, Acumed); 6 (ITS); 7 (Elsevier); 8 (J Orthopaedic Trauma); 9 (OTA, Hip Society, COA)*
Schenker, Mara	*3B (Miami Device Solutions; Carmell Therapeutics)*
Schep, Niels	*(n)*
Schepers, Tim	*(n)*
Schipper, Inger	*(n)*
Schirmers, Joseph	*(n)*
Schiro, Sharon	*(n)*
Schlechter, John	*(n)*
Schmidt, Andrew	*1 (Smith & Nephew); 3B (Acumed, Conventus Orthopaedics); 4 (Conventus, Twin Star Medical, EPIX Orthopedics, PreferUS Healthcare, EPIEN); 7 (Thieme); 8 (J Bone Joint Surgery EST, J Knee Surgery)*
Schneider, Prism	*(n)*
Schoonover, Carrie	*(n)*
Schott, Eric	*(n)*
Schottel, Patrick	*3B (CD Diagnostics)*
Schreiber, Christine (OTA Staff)	*(n)*
Schroder, Lisa	*(n)*
Schroeder, Amanda	*(n)*
Schuetze, Konrad	*(n)*
Schwartz, Alexandra	*2 (Synthes - speaker); 3A (Zimmer - husband employed); 4 (Zimmer - husband)*
Schwartz, Andrew	*(n)*
Sciadini, Marcus	*3B (Stryker Orthopaedics; Globus Medical); 4 (Stryker Orthopaedics)*
Scolaro, John	*3B (Stryker, Smith & Nephew, Zimmer Biomet, Globus Medical)*
Scott, Chloe	*(n)*
Scott, Meredith	*(n)*
Seamon, Jesse	*(n)*
Seeherman, Howard	*3A (Bioventus); 4 (Bioventus); 5 (Bioventus)*
Seeto, Brian	*4 (Johnson & Johnson, Stryker)*
Segers, Michiel	*3B (DePuySynthes); 5 (DePuySynthes)*
Segina, Daniel	*2 (3M, Biomet, Breg, Eli Lilly, Stryker); 3B (Breg, Eli Lilly, Stryker); 4 (Breaking Away Consulting, Genesis Medical Devices- Personal LLC, Motion Devices)*
Seligson, David	*3B (Styker); 5 (Pacira Pharma); 7 (Springer); 9 (Kuntscher Society)*
Sellan, Michael	*(n)*
Sems, Andrew	*1 (Zimmer Biomet)*
Sen, Milan	*2 (Smith & Nephew, Stryker); 3B (Stryker); 9 (AAOS, American Society for Surgery of the Hand, Orthopaedic Trauma Association)*
Sepehri, Aresh	*(n)*
Serino, Joseph	*(n)*

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Serrano, Rafael	*(n)*
Seymour, Rachel	*(n)*
Shaath, Mohamad	*(n)*
Shabtai, Lior	*(n)*
Shafiq, Babar	*5 (Arthrex)*
Shah, Anjan	*(n)*
Shah Kalawar, Rosan	*(n)*
Shamaa, Tayseer	*(n)*
Shank, Nicholas	*(n)*
Shannon, Steven	*(n)*
Shea, Phelan	*(n)*
Shearer, David	*(n)*
Sheehan, Katie	*(n)*
Shen, Xi	*(n)*
Sheu, Robert	*(n)*
Shillingford, Jamal	*(n)*
Shirley, Zachary	*(n)*
Shirtliff, Mark	*4 (Serenta, CelerDx)*
Shozda, Barbara (OTA Staff)	*(n)*
Siebler, Justin	*(n)*
Siegel, Judith	*7 (Wolters Kluwer Health - Lippincott Williams & Wilkin)*
Sierevelt, Inger	*(n)*
Sietsema, Debra	*(n)*
Sims, Alex	*(n)*
Sin, Danielle	*(n)*
Singer, Adam	*(n)*
Sirkin, Michael	*(n)*
Siska, Peter	*(n)*
Sleat, Graham	*(n)*
Slobogean, Gerard (Program Committee)	*2 (Zimmer Biomet); 5 (OTA); 8 (J Orthopaedic Trauma); 9 (OTA Program Committee, AO Trauma North America Research Committee)*
Smeeing, Diederik	*(n)*
Smith, Christopher	*2 (AO North America); 9 (Military Committee, OTA)*
Smith, Jeffrey	*8 (Associate Editor - Patient Safety in Surgery); 9 (OTA PR Committee Chair)*
Smith, Jordan	*(n)*
Smith, Malcolm	*2 (Biomet, Synthes); 3B (Globus Medical); 8 (KCI)*
Smith, Raymond	*3B (Acelity, Globus, Synthes.); 9 (Injury)*

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Smith, Scott	*(n)*
Smith, Wade	*(n)*
Smits, Arjen	*(n)*
Smoak, Jason	*(n)*
Snider, Rebecca	*(n)*
Snoap, Tyler	*(n)*
Sobolev, Boris	*(n)*
Soles, Gillian	*(n)*
Song, Hyung Keun	*(n)*
Song, Wei	*(n)*
Soni, Shalin	*(n)*
Sop, Aaron	*(n)*
Sorg, Debi	*(n)*
Sorkin, Anthony	*2 (Stryker); 3B (Stryker); 4 (Johnson & Johnson, Stryker)*
Southam, Brendan	*(n)*
Sparks, Charisse	*3A (Johnson and Johnson); 6 (Employed by Johnson and Johnson)*
Spellman, Aimee (OTA Staff)	*(n)*
Spiegel, David	*7 (Springer); 9 (AAOS, POSNA)*
Spitler, Clay	*2 (AO North America); 8 (Journal of Bone and Joint Surgery manuscript editor); 9 (AAOS Orthopedic Knowledge Update Evaluation Committee)*
Spraggs-Hughes, Amanda	*(n)*
Sprague, Sheila	*(n)*
Stafford, Paul	*(n)*
Stahel, Philip	*(n)*
Staley, Christopher	*(n)*
Stambough, Jeffrey	*(n)*
Stannard, James	*3B (Acelity, Arthrex, DePuy Synthes, NuVasive, Smith & Nephew); 5 (Arthrex, Coulter Foundation, Department of Defense); 7 (Thieme); 8 (Journal of Knee Surgery (editor-in-chief)); 9 (AO North America (President), Orthopaedic Trauma Assn. (Committee Chair, Bylaws and Hearings Committee))*
Starovoyt, Anastasiya	*(n)*
Starr, Adam	*1 (Starrframe, LLC)*
Steeby, Shaun	*(n)*
Steele, Clarence	*(n)*
Steimer, David	*(n)*
Stein, Deborah	*(n)*
Steinert, Justin	*(n)*
Stelma, Sarah	*(n)*

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Stelzer, John	*(n)*
Stephen, David	*(n)*
Stern, Peter	*(n)*
Stewart, Christopher	*2 (Mallinkrodt, Amniox)*
Stinner, Daniel	*9 (Orthopaedic Trauma Association, Society of Military Orthopaedic Surgeons)*
Stirling, Paul	*(n)*
Stockburger, Christopher	*(n)*
Stockton, David	*(n)*
Stone, Trevor	*(n)*
Stoops, Kyle	*(n)*
Strauch, Robert	*8 (american academy of orthopaedic surgeons, Journal of Hand Surgery - American); 9 (American Society for Surgery of the Hand)*
Strelzow, Jason	*(n)*
Streubel, Philipp	*3B (Acumed, LLC)*
Streufert, Benjamin	*(n)*
Stufkens, Sjoerd	*(n)*
Sucato, Daniel	*(n)*
Sutphin, Patrick	*2 (Cook Medical, Inc); 4 (Stock in Gilead Pharmaceuticals, Valeant Pharmaceuticals); 5 (BTG PLC, local PI for EPOCH study)*
Swafford, Rachel	*(n)*
Swann, Matthew	*(n)*
Swart, Eric	*(n)*
Swenning, Todd	*2 (Mallinckrodt); 3B (Stryker); 8 (Editorial Board: Patient Safety in Surgery); 9 (OTA Health Policy Committee, Board Member IMA Helps)*
Swiontkowski, Marc	*(n)*
Tabrizi, Payam	*(n)*
Taitsman, Lisa	*2 (AONA); 8 (Journal of Orthopaedic Trauma, Geriatric Orthopaedic Surgery & Rehabilitation); 9 (AOA, OTA)*
Tan, Hiang Boon	*(n)*
Tang, Peifu	*(n)*
Tanner, Stephanie	*(n)*
Tantigate, Direk	*(n)*
Tarkin, Ivan	*(n)*
Tatro, Joscelyn	*(n)*
Taylor, Benjamin	*1 (Zimmer Biomet); 2 (Zimmer Biomet); 7 (Orthobullets); 8 (Orthobullets)*
Taylor, Martin	*2 (Bioventus, Zimmer Biomet); 3B (Smith & Nephew)*
Taylor, Michel	*(n)*
Teague, David	*8 (JOT); 9 (OTA)*

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Tejwani, Nirmal	*3B (Zimmer; Stryker); 9 (Orthopaedic Trauma Association)*
Templeman, David	*2 (Stryker, Zimmer); 3B (Orthofix, Inc, Stryker, Zimmer); 4 (Naroflex); 7 (Zimmer)*
Teri, Nicholas	*(n)*
Tetsworth, Kevin	*2 (Stryker, Smith and Nephew); 3B (Smith and Nephew); 9 (AAOS - International Committee; ASAMI-BR International - President)*
Teuben, Michel	*(n)*
Teunis, Teun	*3B (AO, Synthes); 4 (PATIENT+); 5 (ZonMw, CZ); 8 (4Bone, 4Plastics)*
Thabet Hagag, Ahmed	*(n)*
Thayer, Mary	*(n)*
Theologis, Alexander	*5 (Synthes)*
Theyskens, Nina	*(n)*
Thomas, Richard	*(n)*
Thompson, Rachel	*(n)*
Thomson, Seamus	*(n)*
Tidwell, John	*(n)*
Tieszer, Christina	*(n)*
Tissue, Camden	*(n)*
Titus, Alexander	*(n)*
Tomanguillo Chumbe, Julton	*(n)*
Tompane, Trevor	*(n)*
Toney, Eugene	*(n)*
Torbert, Jesse	*(n)*
Tornetta, III, Paul	*1 (Smith & Nephew); 7 (Wolters Kluwer Health - Lippincott Williams & Wilkins); 8 (Journal of Orthopaedic Trauma)*
Tosounidis, Theodoros	*(n)*
Tosteson, Anna	*(n)*
Touban, Basel	*(n)*
Trauma Research Consortium, Major Extremity	*(n)*
Trenholm, J Andrew	*(n)*
Truntzer, Jeremy	*(n)*
Tsai, Stanley	*3A (Apex Biomedical, LLC)*
Tsismenakis, Antonios	*(n)*
Tuck, Christopher	*(n)*
Tucker, Adam	*(n)*
Tucker, Michael	*(n)*
Tuinebreijer, Wim	*(n)*
Tullar, Jessica	*(n)*

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Twigt, Bas	*(n)*
Umpierrez, Monica	*(n)*
Usoro, Andrew	*(n)*
Vachhani, Kathak	*(n)*
Vaidya, Rahul	*1 (Synthes Depuy Johnson and Johnson, Smith and Nephew); 2 (AO North America); 5 (Smith and Nephew, Johnson Johnson Depuy Synthes); 8 (Editorial Board Journal of Orthopaedic Trauma, European Spine Journal)*
Vallier, Heather	*8 (Ed Bd JOT); 9 (OTA, COTA boards)*
Van Besien, Richard	*(n)*
Van der Gronde, Bonheur	*(n)*
van der Vliet, Quirine	*(n)*
Van der Zwaal, Peer	*(n)*
Van Osten, G. Karl	*2 (Zimmer Biomet); 3B (Zimmer Biomet)*
Van Zuthpen, Stephan	*(n)*
VandenBerg, James	*(n)*
Vanderploeg, Eric	*3A (Bioventus, LLC); 4 (Bioventus, LLC)*
Vanderslice, April	*(n)*
Vang, Sandy	*(n)*
Velleman, Jos	*(n)*
Verbeek, Diederik	*(n)*
Verhofstad, Michael	*2 (Johnson and Johnson)*
Verleisdonk, Egbert	*(n)*
Verma, Ravi	*(n)*
Vermaak, Pieter	*(n)*
Vicente, Milena (Lynn)	*(n)*
Virkus, Walter	*3A (Novartis Pharmaceuticals); 3B (Stryker Orthopedics); 4 (Stryker, Johnson and Johnson)*
Viskontas, Darius	*5 (Stryker, Synthes)*
Vodovotz, Yoram	*4 (Immunetrics, Inc.); 8 (International Journal of Burns and Trauma (Associate Editor in Chief); member of editorial board: Shock, Journal of Critical Care, Annals of Translational Medicine, Hepatology, Frontiers in Physiology))*
Volgas, David	*2 (AO Foundation)*
Von Keudell, Arvind	*(n)*
Vorhies, John	*(n)*
Vrabec, Gregory	*8 (Reviewer for the Journal of Orthopaedic Trauma)*
Vu, Catphuong	*(n)*
Wadenpfuhl, Leanne	*(n)*
Wagland, Susan	*(n)*
Wagstrom, Emily	*(n)*

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Walenkamp, Monique	*(n)*
Walker, Brock J.	*(n)*
Wally, Meghan	*(n)*
Wang, Christopher	*1 (Biomet, Seaspine, Aesculap, Amedica, Synthes); 4 (Bone Biologics, Expanding Ortho, Pearldiver, Flexuspine, Fziomed, Benvenue, Promethean, Nexgen, Electrocore, Surgitech); 8 (Spine, JAAOS, The Spine Journal, Clinical Spine Surgery, Global Spine Journal); 9 (North American Spine Society, AOSpine, Cervical Spine Research Society)*
Wang, Jeffrey	*1 (Biomet, Seaspine, Aesculap, Amedica, Synthes); 4 (Bone Biologics, Expanding Ortho, Pearldiver, Flexuspine, Fziomed, Benvenue, Promethean, Nexgen, Electrocore, Surgitech); 8 (Spine, JAAOS, The Spine Journal, Clinical Spine Surgery, Global Spine Journal); 9 (North American Spine Society, AOSpine, Cervical Spine Research Society)*
Wang, Yan	*(n)*
Wang, Yufa	*(n)*
Wanke, Tyler	*3B (EDGe Surgical, Inc.); 4 (EDGe Surgical Inc.);*
Ward, Anthony	*9 (President, South West Orthopaedic Club, UK; RSPA Royal College of Surgeons of England)*
Ward, Jayne	*(n)*
Warmoth, Patrick	*(n)*
Wasserstein, David	*(n)*
Wassick, Michael	*(n)*
Watson, David	*2 (Corin U.S.A., Smith & Nephew); 3B (Corin U.S.A., Smith & Nephew)*
Watson, J Tracy	*1 (Smith and Nephew, Zimmer/Biomet, AOS); 3B (Nuvasive); 9 (OTA Fellowship Committee and Fund development Committee, Chairman AAOS bilologic Implant committee)*
Weatherford, Brian	*3B (Lineage Medical LLC (Orthobullets), BESPA Global)*
Weaver, Michael	*(n)*
Webb, Lawrence	*2 (Musculoskeletal Transplant Foundation); 3B (Biocomposites); 6 (Kinetic Concepts, Doctors Group, Smith & Nephew, Stryker, Synthes); 9 (Orthopaedic Trauma Association Southeastern Fracture Consortium Foundation)*
Webber, Annie	*(n)*
Weber, Timothy	*(n)*
Wegener, Stephen	*(n)*
Weil, Yoram	*(n)*
Weinlein, John	*1 (Elsevier)*
Weinstock, Laura	*(n)*
Weiss, David	*3B (Globus Medical); 7 (Lippincott)*
Wellman, David	*4 (Imagen)*
Welsh, Christopher	*(n)*
Welsh, Matthew	*(n)*
Wenke, Joseph	*(n)*
Wessel, Lauren	*(n)*
Wessel, Robert	*(n)*

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Westberg, Jerald	*(n)*
Weston, Ian	*(n)*
White, Neil	*3B (Bioventus); 5 (Bioventus)*
White, Timothy	*(3C (Acumed); 5 (Acumed, Smith and Nephew); 6 (Smith and Nephew)*
Whiting, Paul	*(n)*
Whyne, Cari	*5 (Baylis Medical, Calavera, Medtronic, Synaptive, XLV)*
Wilber, John	*(n)*
Wilken, Jason	*(n)*
Wilkinson, Brandon	*(n)*
Will, Ryan	*(n)*
Willett, Keith	*1 (Zimmer for implant design - wholly unrelated to this research)*
Willett, Nick	*(n)*
Willey, Michael	*(n)*
Williams, Benjamin	*(n)*
Wilson, Christopher	*3A (Bioventus, LLC)*
Wilson, Jacob	*(n)*
Wilson, Philip	*(n)*
Wimberly, Robert	*1 (Elsevier textbook royalities); 5 (Smith and Nephew reduced cost supplies for biomechanical study; Orthopediatrics donated implant for biomechanical study)*
Windahl, Matthew	*(n)*
Winkler, Craig	*(n)*
Winson, Ian	*1 (Corin UK for Ankle Replacement design); 8 (BJJ Board of management); 9 (BOA President)*
Winston, Benjamin	*(n)*
Winston, Mark	*(n)*
Wiper, Jay	*(n)*
Wise, Brent	*(n)*
Wiss, Donald	*7 (Wolters Kluwer Health - Lippincott Williams & Wilkins)*
Wixted, John	*3B (DePuy, A Johnson & Johnson Company); 5 (Merck)*
Wojahn, Robert	*(n)*
Wolinsky, Philip	*2 (Zimmer Biomet); 8 (JOT); 9 (ACS, AAOS, OTA)*
Woltz, Sarah	*(n)*
Wong, Merng	*(n)*
Wong, Merng Koon	*2 (Synthes); 5 (Synthes); 9 (AO Foundation)*
Wood, Levi	*3A (MiMedx)*
Wood, William	*(n)*
Working, Zachary	*(n)*
Wozney, John	*3B (Bioventus LLC)*

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Wright, Raymond	*(n)*
Wu, Hao-Hua	*(n)*
Wu, Yi-Hung	*(n)*
Wyles, Cody	*(n)*
Wyrick, John	*2 (Smith and Nephew); 3B (Stryker)*
Wysong, Elena	*(n)*
Xi, Min	*(n)*
Xiong, Grace	*(n)*
Yang, Kyu-Hyun	*1 (Zimmer-Biomet); 2 (Zimmer-Biomet); 3B (Zimmer-Biomet)*
Yapp, Liam	*(n)*
Yeo, Do-Hyun	*(n)*
Yeung, Caleb	*(n)*
Yoo, Brad	*(n)*
Yoo, Minkyoung	*(n)*
Yoon, Richard	*3A (Orthobullets); 7 (IGI Global; Springer Books)*
Young, Heather	*(n)*
Yuan, Brandon	*(n)*
Zdero, Radovan	*5 (Sawbones, Stryker, Smith & Nephew, Depuy); 7 (Elsevier Inc); 8 (Journal of Orthopaedic Trauma, Biomed Research International, Journal of Medical Engineering)*
Zeldin, Roseann	*(n)*
Zelenty, William	*(n)*
Zhang, Jun	*(n)*
Zhang, Mei	*(n)*
Zhao, Jiwei	*(n)*
Zheng, Xuan	*(n)*
Zhou, Qi	*(n)*
Zipunnikov, Vadim	*(n)*
Ziran, Bruce	*(n)*
Zirkle, Lewis	*(n)*
Zuelzer, David	*(n)*
Zuscik, Michael	*(n)*
Zych, Gregory	*(n)*

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Kathleen Caswell – Executive Director Representative

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James R Ficke
A Alex Jahangir
Clifford Jones
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Mark P McAndrew
Anna Miller
H Claude Sagi
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Robert O'Toole – EWI Civilian Rep 2018
Andrew Schmidt – EWI Oversight Chair

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Brett D. Crist, MD, Director

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Harborview Medical Center, Seattle, WA
David P. Barei, MD, Director

John Esposito, MD and **Jeffrey Potter, MD**
Harvard Orthopaedic Trauma, Boston, MA
Michael Weavers, MD, Director

John Whatley, MD and **Jill Martin, MD**
Hennepin County Medical Center, Minneapolis, MN
David C. Templeman, MD, Director

Diren Arsoy, MD, **Adam C. Shaner, MD** and **Camden M. Tissue, MD**
Hospital for Special Surgery, New York, NY
David L. Helfet, MD, Director

2016-2017 OTA Fellowship Graduating Class, continued

Raymond Long, MD
Hughston Orthopaedic Trauma Service (HOTS), Columbus, GA
John C. P. Floyd, MD, FACS, Director

Landon Fine, MD and **Charlie Lieder, MD**
IU Methodist Orthopaedic Trauma Fellowship, Indianapolis, IN
Anthony T. Sorkin, MD, Director

George R. Hanson, MD
MetroHealth Medical Center, Cleveland, OH
John H. Wilber, MD, Director

Richard Yoon, MD
Orlando Regional Medical Center, Orlando, FL
George Haidukewych, MD, Director

Charlotte Orr, MD
OrthoIndy, Indianapolis, IN
Timothy Weber, MD, Director

Kelly Brossy, MD
Orthopaedic Trauma Surgeons of Northern California, Carmichael, CA
Paul Gregory, Jr. MD, Director

Edward Sirlin, MD
Penn State University, College of Medicine, Hershey, PA
J. Spence Reid MD, Director

Suneel Bhat, MD, **Mark Gage, MD**, **Michael Maceroli, MD**, **David Potter, MD** and **Brent Wise, MD**
R Adams Cowley Shock Trauma Center, Baltimore, MD
Robert V. O'Toole, MD, Director

Cory Carlston, MD
Regions Trauma Center/Univ. of Minnesota Orthopaedic, St. Paul, MN
Peter A. Cole, MD, Director

David Swanson, MD
Reno Orthopaedic Trauma Fellowship, Reno, NV
Timothy Bray, MD, Director

2016-2017 OTA Fellowship Graduating Class, continued

Adam W. Gitlin, MD
Rutgers New Jersey Medical School, Newark, NJ
Mark Reilly, MD, Director

Kim M. Ruby, MD
San Diego Trauma Fellowship, San Diego, CA
Jeffrey M. Smith, MD, Director

Matthew Baker, MD
St. Louis University, Saint Louis, MO
J. Tracy Watson, MD, Director

Patrick Horrigan, MD
Stanford University, Redwood City, CA
Michael J. Bellino, MD and *Michael Gardner, MD, Directors*

Joseph Christensen, MD, **Matthew Frank, MD** and **Brett Barrick, MD**
Tampa General Hospital, Tampa, FL
Roy Sanders, MD, Director

Laurence Cook, MD and **Reilly Kuehn, MD**
University of California (Davis) Medical Center, Sacramento, CA
Mark A. Lee, MD, Director

William T. Kent, MD
University of California, San Diego, San Diego, CA
Alexandra K. Schwartz, MD, Director

Karl Frank Siebuhr, MD and **Adrian Huang, MB, BCh, BAO, FRCSC**
University of California, San Francisco, San Francisco, CA
Theodore Miclau, MD, Director

Sunny Gupta, MD
University of Florida, College of Medicine, Gainesville, FL
Kalia K. Sadasivan, MD, Director

Alesha Scott, DO
University of Kentucky, Lexington, KY
Raymond D. Wright, Jr., MD, Director

2016-2017 OTA Fellowship Graduating Class, continued

Dhavalkumar Patel, MD, **Saygin Kamaci, MD** and **Jin Young Kim, MD**
University of Louisville School of Medicine, Louisville, KY
David Seligson, MD, Director

Amir Shapira, MD
University of Miami/Jackson Memorial Medical Center, Miami, FL
Gregory Zych, DO, Director

Tina Dreger, MD and **Kyle Schweser, MD**
University of Missouri, Columbia, MO
Brett D. Crist, MD, Director

Samer Kakish, MD
University of New Mexico Hospital, Albuquerque, NM
Thomas A. DeCoster, MD, Director

Zachary Nollin, MD
University of Oklahoma, Tulsa, OK
Brent Norris, MD and *Paul Stafford, MD, Directors*

Mark Ayoub, MD
University of Pittsburgh, Pittsburgh, PA
Ivan S. Tarkin and *Peter Siska, MD, Directors*

Eric A. Barcak, DO
University of Tennessee - Campbell Clinic, Memphis, TN
John Weinlein, MD and *Matthew Rudloff, MD, Directors*

Elliot R. Row, MD
University of Tennessee/Erlanger Health Systems, Chattanooga, TN
Peter J. Nowotarski, MD, Director

Steven Cherney, MD, **Bryce Cunningham, MD** and **Stephen Warner, MD, PhD**
University of Texas Health Science Center at Houston, Houston, TX
Timothy S. Achor, MD, Director

Ryan Michels, MD
UT Southwestern/Parkland Health & Hospital System, Dallas, TX
Adam J. Starr, MD, Director

2016-2017 OTA Fellowship Graduating Class, continued

Adam K. Lee, MD and **Seth Cooper, MD**
Vanderbilt University Medical Center, Nashville, TN
Cory Collinge, MD, Director

Nirav K. Patel, MD
Virginia Commonwealth University, Richmond, VA
Varatharaj Mounasamy, MD, Director

Eddie Keith Hasty, MD
Wake Forest University, Winston-Salem, NC
Eben A. Carroll, MD, Director

Matthew Avery, MD
Washington University School of Medicine/Barnes-Jewish Hospital, Saint Louis, MO
William Ricci, MD, Director

Amanda Wright, MD
Wright State University, Dayton, OH
Michael J. Prayson, MD, Director

James Kesl, DO
York Hospital, York, PA
Thomas DiPasquale, DO, FACOS, FAOAO, Director

AWARDS

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 Recipients:

2017 – ***Kristoffer Roland Uy Roa, MD*** *- Davao Del Sur, Philippines*
John Ekure, MD *- Kumi, Uganda*

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.

2016 – In a Climate of Healthcare as a Commodity, What is the Role of the Individual Surgeon?
Keith A. Mayo, 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.

2016 – Simple Decompression versus Anterior Transposition of the Ulnar Nerve for Distal Humerus Fractures Treated with Plate Fixation: A Multi Centre Randomized Controlled Trial
Emil H. Schemitsch, MD; Niloofar Dehghan, MD, MS, FRCSC; Milena Vicente, RN; Aaron Nauth, MD, FRCSC; Jeremy Hall, MD, FRCS (ORTHO), MEd; Michael D. McKee, MD; COTS (Canadian Orthopaedic Trauma Society)

2017 OTA AFA COMMUNITY SURGEON ACHIEVEMENT AWARD* RECIPIENT

**Orthopaedic Trauma Association (OTA) and American Fracture Association (AFA) co-founded this annual award in 2017.*

2017 – Bruce H. Ziran, MD, FACS

OTA 2017 RESEARCH GRANT AWARD RECIPIENTS

(January 1, 2017 - December 31, 2017 Grant Cycle)

CLINICAL GRANT AWARDS (up to $40,000/year, 2-year grant cycle)

Title: **Cognitive Behavioural Therapy to Prevent Persistent Post-Surgical Pain following Surgical Repair of Extremity Fractures: A Feasibility Study**
Principal Investigator: **Jason Busse, MSc, PhD**
Co-Principal Investigator: **Mohit Bhandari, MD**
Awarded Funds: **$79,991** Grant Funded By: **OTA**

Title: **An Imaging Framework for Clinically Testing New Treatments to Prevent Post-traumatic OA**
Principal Investigator: **Donald D Anderson, BS, MS, PhD**
Co-Principal Investigator: **J. Lawrence Marsh, MD**
Awarded Funds: **$79,982** Grant Funded By: **OTA/Zimmer**

Title: **Outcomes in Distal Radius Fractures: A Multicenter Prospective Cohort Study**
Principal Investigator: **Emil H Schemitsch, MD**
Co-Principal Investigator: **Michael McKee, MD**
Awarded Funds: **$79,050** Grant Funded By: **OTA/Smith and Nephew**

DIRECT TOPIC RESEARCH GRANTS (up to $50,000/year, max. up to 3-year grant cycle)

Title: **A Blinded Exploratory Randomized Controlled Trial to Determine Optimal Vitamin D3 Supplementation Strategies for Acute Fracture Healing**
Principal Investigator: **Gerard P Slobogean, MD, MPH, FRCSC**
Co-Principal Investigator: **Sheila Sprague, MD**
Awarded Funds: **$150,000** Grant Funded By: **OTA**

DIRECT TOPIC OTA/AOTNA RESEARCH GRANTS (up to $50,000/year, max. up to 2-year grant cycle)

Title: **Development and Testing of Pre-Injury Computer Adaptive Test for Orthopaedic Trauma**
Principal Investigator: **Ami Stuart, PhD**
Co-Principal Investigator: **Thomas Higgins, MD**
Awarded Funds: **$52,650** Grant Funded By: **OTA/AOTNA**

OTA 2017 DIRECTED TOPIC GRANT RECIPIENTS

(June 1, 2017 - May 31, 2018 Grant Cycle)

Title: **Does the Use of Liposomal Bupivacaine Decrease Narcotic Requirements in Geriatric Hip Fractures? A Randomized, Double Blinded Control Trial**
Principal Investigator: **Eric Swart, MD**
Co-Investigator: **Paul Matuszewski, MD**
Amount Funded: **$49,500** Grant Funded By: **Pacira**

TOTAL OTA MEMBER GRANTS AWARDED: **$491,173**

OTA 2017 RESIDENT GRANT RECIPIENTS

(January 1, 2017 - December 31, 2017 Grant Cycle)

Grant Title: **Opioid Utilization After Rotational Ankle Fractures: A Prospective Interventional Study Utilizing Mobile Phones and Software Communication**
Principal Investigator: **Chris A Anthony, MD**
Co-Investigators: **Matt Karm, MD, Apurva Shah, MD, John Marsh, MD**
Awarded Funds: **$20,000** Grant Funded By: **OTA/FOT**

Grant Title: **Finding a Clinically Translatable Suspension Medium for EPC Therapy in Orthopaedics**
Principal Investigator: **Ian Whatley, MD**
Co-Investigator: **Aaron Nauth, MD**
Awarded Funds: **$20,000** Grant Funded By: **OTA/DePuy Synthes**

Grant Title: **Inhibitory Effects of Cigarette Smoke on Endochondral vs Intramembranous Fracture Healing Pathways in a Bilateral Femur Fracture Rat Model**
Principal Investigator: **Evan Lexworth Hanna, MD**
Co-Investigators: **Kristoff Reid, MD, Vincent Pellegrini, MD**
Awarded Funds: **$20,000** Grant Funded By: **OTA/FOT**

Grant Title: **Ligamentous Lisfranc Injuries: Is Locked Dorsal Plate Fixation Biomechanically Superior than Transarticular Screws?**
Principal Investigator: **Ankit Bansal, MD**
Co-Investigator: **Stephen Kates, MD**
Awarded Funds: **$10,000** Grant Funded By: **OTA/DePuy Synthes**

Grant Title: **Assessing Risk of Opioid Dependence in Trauma Patients: Biomarkers and Attentional Bias of Abuse (AROD)**
Principal Investigator: **Anna van der Horst, MD**
Co-Investigator: **Thomas Higgins, MD**
Awarded Funds: **$20,000** Grant Funded By: **OTA/FOT**

TOTAL RESIDENT GRANTS AWARDED: **$90,000**

OTA 2017 RESIDENT GRANT RECIPIENTS

(June 1, 2017 - May 31, 2018 Grant Cycle)

Grant Title: **A Retrospective Cohort Study Examining Complications in the Treatment of Distal Radius Fractures in an Adult Population**
Principal Investigator: **Joel Moktar, BSc, MD**
Co-Investigators: **Emil Schemitsch MD, Lauren Nowak MSc, Michael McKee MD**
Amount Funded: **$19,629.32** Grant Funded by: **OTA**

Grant Title: **Delayed Endothelial Progenitor Cell Therapy for Chronic Bone Defect Repair**
Principal Investigator: **Jonathan Peck, MD**
Co-Investigator: **Aaron Nauth, MD**
Amount Funded: **$20,000** Grant Funded by: **OTA**

Grant Title: **GSK3 Antagonists to Stimulate Bone Healing**
Principal Investigator: **Magdalena Tarchala, MD**
Co-Investigator: **Edward Harvey, MD**
Amount Funded: **$19,020** Grant Funded by: **OTA**

Grant Title: **Does Contact Stress Better Predict PTOA and Patient Outcomes in Patients with Displaced Acetabular Fractures Following ORIF?**
Principal Investigator: **Tyler L Carllee, MD**
Co-Investigators: **Don Anderson, PhD, Mike Willey, MD**
Amount Funded: **$20,000** Grant Funded by: **OTA**

TOTAL RESIDENT GRANTS AWARDED: **$78,649.32**

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.

Annual Meeting 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 33rd Anniversary Annual Meeting of the OTA will allow all registrants to:

- Discuss and highlight recently presented prospective clinical trials in orthopaedic trauma
- Summarize evidence - based recommendations for the treatment of common fractures
- Knowledge transfer to initiate practice change to include treatment strategies based on evidence - based medicine
- Describe the benefits of an integrated national trauma network
- Identify consensus opinions on many current issues and controversies regarding the treatment of infected fractures.

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 **20** ***AMA PRA Category 1 Credits***™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

ACCREDITATION – CME INFORMATION

The Basic Science Focus Forum and International Trauma Care Forum have 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 designates the live activity of the Basic Science Focus Forum for a maximum of **11.75** ***AMA PRA Category 1 Credits***™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

The American Academy of Orthopaedic Surgeons designates the live activity of the International Trauma Care Forum for a maximum of **10.5** ***AMA PRA Category 1 Credits***™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

The 33rd 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 **20** ***AMA PRA Category 1 Credits***™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

FDA STATEMENT

All drugs and medical devices used in the United States are administered in accordance with the Food and Drug Administration (FDA) Regulations. These regulations vary depending on the risks associated with the drug or medical device, the similarity of the drug or medical device to products already on the market, and the quality and scope of clinical data available.

Some drugs or medical devices described or demonstrated in OTA educational materials or programs have not been cleared by the FDA or have been cleared by the FDA for specific uses only. The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or device s/he wishes to use in clinical practice.

DISCLAIMER

The material presented at the 33rd 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 33rd 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.

Δ Indicates presentation was funded by a grant from the Orthopaedic Trauma Association.

Cameras or video cameras may not be used in any portion of the meeting.

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. Disclosure information is to be submitted through the AAOS on-line Disclosure Program (or other disclosure form provided and approved by the OTA Participants are responsible for the accuracy and completeness of their information. In addition, participants who disclose via the AAOS on-line Disclosure Program have an obligation to review and update their personal information in the AAOS Orthopaedic Disclosure Program at least semiannually (usually April and October). It is recommended that participants note any changes to the AAOS Orthopaedic Disclosure Program as soon as possible after they occur.

Failure of a required participant to disclose will result in the participant being asked not to participate in the OTA CME program and OTA governance groups.

A list of all participants in OTA CME programs and OTA governance groups, along with their disclosures, will be included in all meeting materials.

Participants in OTA governance groups have an obligation to indicate any potential conflicts they may have during discussions affecting their personal interests during the meeting of the OTA governance group. At each meeting of the OTA governance group, members of the group will be reminded that full disclosure must be made of any potential conflict of interest when a matter involving that interest is discussed.

The chair of the governance group shall also have the prerogative of requesting a participant to provide further information or an explanation if the chair identifies a potential conflict of interest regarding that participant. Based on the information provided in the OTA Orthopaedic Disclosure Program and/or upon a further review, the chair of the OTA governance group may determine that the participant shall:

Disclose the conflict and continue to participate fully in the OTA governance group's deliberations

Disclose the conflict, but abstain from discussing and voting on the matter; or

Disclose the conflict and leave the room until the matter has been fully discussed and acted upon.

If one of the latter two actions is taken, it should be reflected in the minutes of the OTA governance group's meeting.

Adopted: February 2011
Revised: March 2014

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.

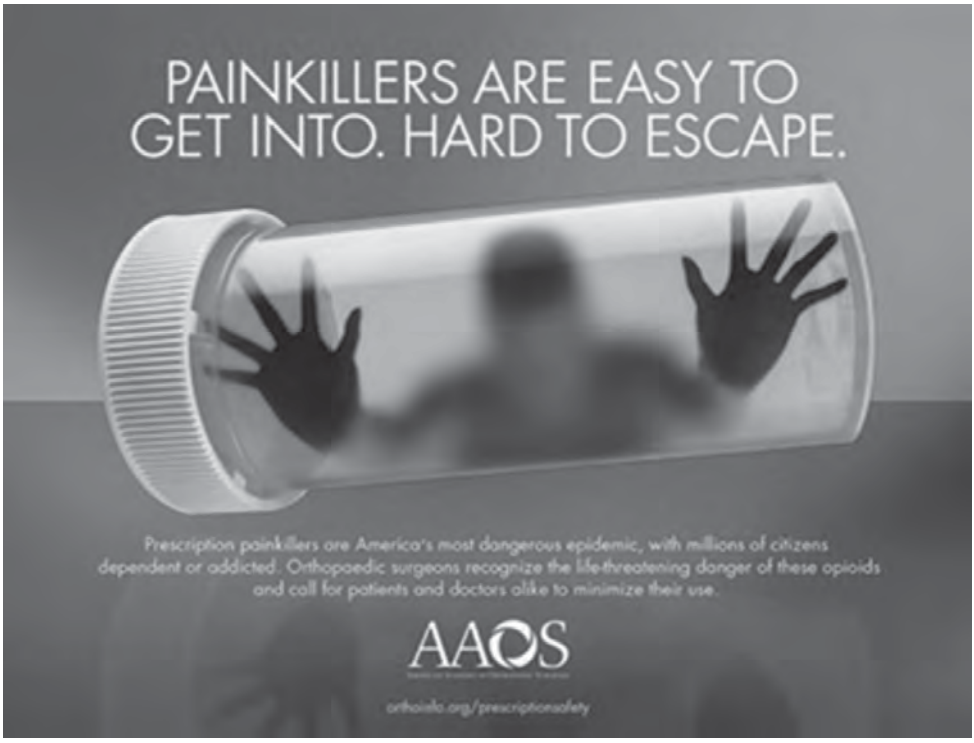
RIDERS AREN'T ALWAYS IN THE RIGHT. BUT THEY ARE ALWAYS FRAGILE.

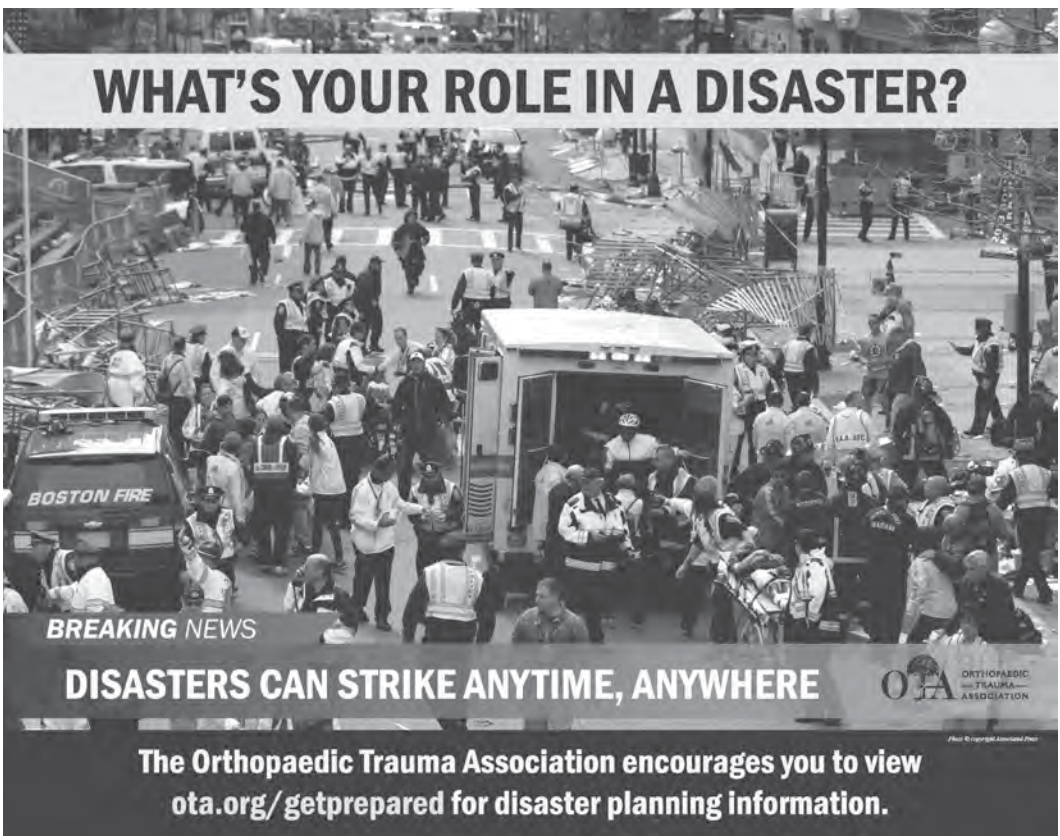
In addition to being vastly outnumbered by cars, bike riders are much more exposed. So, even when a rider does something boneheaded, remember—your broken headlight is easier to fix than their smashed frame. Take the high road and give bicyclists the space they need to ride safely. Check our websites for more road sharing tips.

VISIT ORTHOINFO.ORG/BIKESAFETY

OTA ORTHOPAEDIC TRAUMA ASSOCIATION
ota.org

AAOS AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS
orthoinfo.org


PAINKILLERS ARE EASY TO GET INTO. HARD TO ESCAPE.
Prescription painkillers are America's most dangerous epidemic, with millions of citizens dependent or addicted. Orthopaedic surgeons recognize the life-threatening danger of these opioids and call for patients and doctors alike to minimize their use.
AAOS
orthoinfo.org/prescriptionsafety


WHAT'S YOUR ROLE IN A DISASTER?
BOSTON FIRE
BREAKING NEWS
DISASTERS CAN STRIKE ANYTIME, ANYWHERE
OTA
ORTHOPAEDIC TRAUMA ASSOCIATION
The Orthopaedic Trauma Association encourages you to view ota.org/getprepared for disaster planning information.

OTA GRATEFULLY ACKNOWLEDGES THE FOLLOWING EXHIBITORS FOR THEIR SUPPORT OF THE 33RD ANNUAL MEETING:

Booth #	Company Names	City, State
719	**aap Implantate AG**	Berlin, Germany
410	**Acelity**	San Antonio, TX
225	**Acumed, LLC**	Hillsboro, OR
Office H	**Acumed, LLC**	Hillsboro, OR
311	**Advanced Orthopaedic Solutions**	Torrance, CA
518	**AOTrauma North America**	Paoli, PA
522	**Arbutus Medical**	Vancouver, BC
213	**Arthrex, Inc.**	Naples, FL
703	**Austin Medical Ventures**	Germantown, TN
723	**BioAccess Inc**	Baltimore, MD
620	**Biocomposites**	Wilmington, NC
515	**Bioventus, LLC**	Durham, NC
411	**Bone Foam Inc.**	Corcoran, MN
201	**BONESUPPORT**	Cambridge, MA
219	**CarboFix Orthopedics, Inc**	Ocean Isle Beach, NC
621	**Conventus Orthopaedics, Inc.**	Maple Grove, MN
611, 818	**DePuy Synthes**	West Chester, PA
200	**ECA Medical Instruments**	Thousand Oaks, CA
614	**EDGe Surgical, Inc.**	Chicago, IL
204	**Envision Physician Services**	Dallas, TX
531	**Globus Medical**	Audubon, PA
203	**GPC MEDICAL USA**	Dallas, TX
527	**Histogenics**	Waltham, MA
521	**Hologic**	Marlborough
315	**Innomed, Inc.**	Savannah, GA
612	**Invibio Biomaterials Solutions**	West Conshohocken, PA
618	**ITS**	Maitland, FL
221	**LinkBio Corp**	Rockaway, NJ
427	**MAHE Medical**	Golden, CO
424	**Medartis**	Exton, PA
511	**Medtronic**	Memphis, TN
420	**Miami Device Solutions**	Miami, FL
216	**Microware Precision Co., Ltd.**	Taichung City, Taiwan

EXHIBITORS LISTING, continued

Booth #	Company Names	City, State
320	**MiMedx Group, Inc.**	Marietta, GA
619	**Mizuho OSI**	Union City, CA
327	**NEWCLIP TECHNICS**	Haute Goulaine, France
318	**NuVasive Specialized Orthopedics, Inc.**	Aliso Viejo, CA
Office D	**NuVasive Specialized Orthopedics, Inc.**	Aliso Viejo, CA
319	**Orthofix**	Lewisville, TX
526	**Orthomed Inc.**	Tigard, OR
418	**OTA Classification Committee**	Rosemont, IL
109	**OTA Product Demonstration Theater**	Rosemont, IL
211	**Pacific Instruments**	Honolulu, HI
423	**Pikeville Medical Center, Inc.**	Pikeville, KY
412	**Precision OS**	North Vancouver, BC
626	**Quintus Composites**	Camp Verde, AZ
519	**Sawbones**	Vashon, WA
701	**Sectra NA Inc.**	Shelton, CT
414	**Shukla Medical**	Piscataway, NJ
214	**SI-BONE, Inc.**	San Jose, CA
600	**Smith and Nephew**	Cordova, TN
Offices E,G	**SMV Scientific**	Austin, TX
721	**Spinal Cord Injury and Fragility Fractures**	
205	**Starr Frame LLC**	Richardson, TX
720	**Structure Medical**	Mooresville, NC
401	**Stryker**	Mahwah, NJ
422	**Surgionix**	Auckland, New Zealand
421	**Synergy Surgicalists**	Bozeman, MT
419	**The Bone & Joint Journal**	London, UK
310	**The Orthopaedic Implant Company**	Reno, NV
314	**TriMed, Inc.**	Santa Clarita, CA
323	**Wright Medical Technology**	Memphis, TN
525	**Ziehm Imaging**	Orlando, FL
301	**Zimmer Biomet**	Warsaw, IN
524	**Zimmer Biomet**	Jacksonville, FL
General Session Foyer Area	**Wolters Kluwer**	