LLRS
Limb Lengthening and Reconstruction Society
ASAMI NORTH AMERICA

Limb Lengthening & Reconstruction Society
PHILADELPHIA 2025

34th Annual Scientific Meeting

Limb Lengthening and Reconstruction Society:

ASAMI–North America

July 18 & 19, 2025

The Logan Philadelphia's Hotel

Philadelphia, PA

www.llrs.org

LLRS: ASAMI–North America

Future Meetings

Essentials of Lower Extremity Reconstruction (ELER)

January 23 & 24, 2026

Atlanta, GA

LLRS Specialty Day

March 2026

New Orleans, LA

35th Annual Scientific Meeting

Montreal, Quebec, Canada

Upcoming AAOS Meeting

March 2–6, 2026

New Orleans, LA

For more information:

Karen R. Syzdek, Executive Director

info@llrs.org

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

LLRS: ASAMI–North America
Meetings & Presidents

Year	Location	President
1990	Baltimore, MD	Dror Paley, MD
1991	Kiawah, SC	Stuart A. Green, MD
1993	San Francisco, CA	Alfred D. Grant, MD
1994	New Orleans, LA	Deborah Bell, MD
1995	Orlando, FL	Jason Calhoun, MD
1996	Atlanta, GA	Mark T. Dahl, MD
1997	San Francisco, CA	John Herzenberg, MD
1998	New Orleans, LA	James Aronson, MD
1999	Dana Point, CA	J. Charles Taylor, MD
2000	Lake Buena Vista, FL	Charles T. Price, MD
2001	Berkeley, CA	Richard S. Davidson, MD
2002	Las Colinas, TX	John J. Gugenheim, MD
2003	Boston, MA	James C. Binski, MD
2004	Toronto, Ontario, CANADA	John G. Birch, MD
2005	New York, NY	William G. Mackenzie, MD
2006	San Diego, CA	James. J. Hutson, Jr., MD
2007	Chicago, IL	David W. Lowenberg, MD
2008	Albuquerque, NM	George Cierny, III, MD
2009	Louisville, KY	Paul T. Freudigman Jr., MD
2010	New York, NY	John K. Sontich, MD
2011	Chicago, IL	Doreen DiPasquale, MD
2012	Cincinnati, OH	James J. McCarthy, MD
2013	New York, NY	S. Robert Rozbruch, MD
2014	Montreal, Quebec CANADA	Sanjeev Sabharwal, MD
2015	Miami, FL (ILLRS Congress)	Reggie C. Hamdy, MD
2016	Charleston, SC	Joseph R. Hsu, MD
2017	Park City, UT	Karl Rathjen, MD
2018	San Francisco, CA	Kevin W. Louie, MD
2019	Boston, MA	J. Spence Reid, MD
2020	Virtual	Austin T. Fragomen, MD
2021	New York, NY	Austin T. Fragomen, MD
2022	Portland, OR	Raymond W. Liu, MD
2023	Olympic Valley, CA	L. Reid Nichols, MD
2024	Hollywood, FL	Stephen M. Quinnan, MD
2025	Philadelphia, PA	Christopher A. Iobst, MD

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

President and Program Chair

Christopher A. Iobst, MD, FAOA, FAAOS

Director, Center for Limb Lengthening and Reconstruction

Director, Limb Lengthening and Reconstruction Fellowship

Clinical Associate Professor, Orthopaedic Surgery

The Ohio State University, College of Medicine

Nationwide Children's Hospital

Columbus, OH

614–722–3390

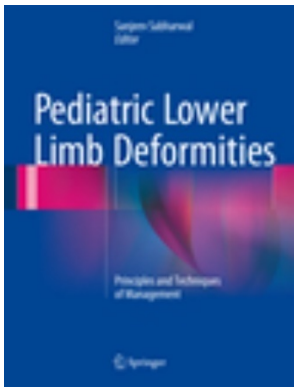
Pediatric Lower Limb Deformities

and

Limb Lengthening and Reconstruction Surgery Case Atlas Series

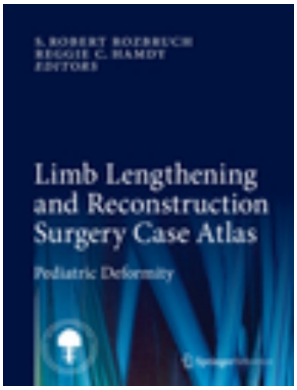
Pediatric Lower Limb Deformities

Sanjeev Sabharwal (Ed.)



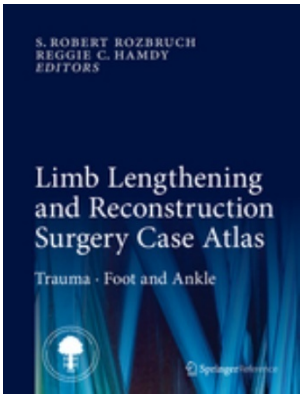
Pediatric Deformity

S. Robert Rozbruch and
Reggie C. Hamdy (Eds.)



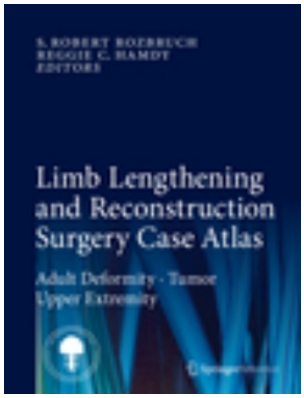
Trauma •
Foot and Ankle

S. Robert Rozbruch and
Reggie C. Hamdy (Eds.)



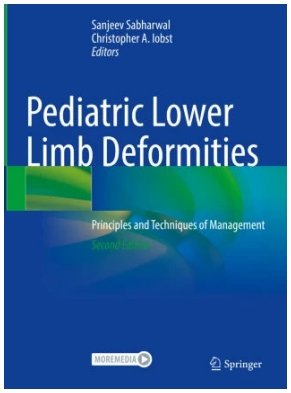
Adult Deformity •
Tumor • Upper Extremity

S. Robert Rozbruch and
Reggie C. Hamdy (Eds.)



Pediatric Lower Limb
Deformities (2024)

Sanjeev Sabharwal and
Christopher A. Iobst (Eds.)



To order, go to www.springer.com • Search “limb lengthening”

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

Please join us!

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July 16–18, 2026

Sofitel Golden Mile

Montreal, Quebec, Canada

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Helpful Web Sites

LLRS: ASAMI–North America

http://www.llrs.org

American Academy of Orthopaedic Surgeons (AAOS)

http://www.aaos.org

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

2024–2025 Officers and Executive Board

President
Christopher A. Iobst, MD

First Vice President
Mitchell Bernstein, MD

Second Vice President
Jill C. Flanagan, MD

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Paul E. Matuszewski, MD

Treasurer
Harold J.P. van Bosse, MD

Members At Large
James A. Blair, MD
Elizabeth Hubbard, MD
Lee Zuckerman, MD

Nominating Committee
L. Reid Nichols, MD, Chair
Stephen M. Quinnan, MD

Education Chair
David A. Podeszwa, MD

Membership Chair
David B. Frumberg, MD

Research Chairman
Jessica C. Rivera, MD, PhD

Immediate Past President
Stephen M. Quinnan, MD

Board of Specialty Societies (BOS) Representatives
Jill C. Flanagan, MD
Mani D. Kahn, MD

Traveling Fellowship Chair, Mentorship Program Chair
Jaclyn F. Hill, MD

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

34th Annual Scientific Meeting

Objectives

Upon completion of LLRS's 34th Annual Scientific Meeting, physicians will be able to:

- apply the latest developments in the orthopedic subspecialties of limb lengthening and reconstruction;
- discuss the principles of tissue generation by distraction (distraction histogenesis); and
- understand surgical techniques of distraction histogenesis.

Selection of Content

Selection of material for presentation during the 34th Annual Scientific Meeting was based on scientific and educational merit. The selection process does not imply the treatment modality or research methodology is necessarily the best or most appropriate available.

LLRS disclaims formal endorsement of methods or research methodology used and further disclaims any and all liability for claims which may arise out of the use of techniques discussed or demonstrated whether those claims shall be asserted by a physician or another person.

Food and Drug Administration

LLRS notes that approval of the FDA or national equivalent of its lists from other countries, is required for procedures and drugs that may be considered experimental. Instrumentation and procedures presented during the Virtual Meeting may not have received the approval of the appropriate federal authority, LLRS supports the use of techniques with requisite government approval only.

Faculty Disclosure

Faculty members are required to disclose whether they have a financial arrangement or affiliation with a commercial entity related to their presentation(s). This disclosure is indicated on the Faculty List. Those marked with *** did not disclose per AAOS guidelines.

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

The LLRS appreciates its Corporate Partners and Exhibitors

Globus Medical Inc.
Thank you for the generous grant

OrthoPediatrics Corp.
Thank you for the generous grant

Smith & Nephew Inc.
Thank you for the generous grant

Stryker Trauma & Extremities
Thank you for the generous grant

Exhibitors

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Thank you for the In–kind Donation

Baltimore Limb Deformity Course

Congenital Limb Deficiencies Deformity Course

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

Exhibitors

(listed in alphabetical order)

The LLRS thanks the following entities for their generous support.

ALM Ortho is focused on supporting surgeons when there are no industry solutions to their patient's complex orthopedic problems. Through our direct collaborations with surgeons, we develop and deliver innovative Orthopedic Implant Solutions for Osseointegration, Limb Lengthening, and Traumatic problems.

LIFEBRIDGE HEALTH
Rubin Institute for Advanced Orthopedics

Baltimore Limb Deformity Course – Register for an intensive course covering deformity correction planning and limb lengthening. An internationally renowned faculty will provide didactic and hands–on lab instruction. Learn about fellowship opportunities. 410–601–9798; click here for the BLDC website

Biocomposites® At Biocomposites, we are proud to be driving improved outcomes across a wide range of clinical applications for patients and surgeons. Our team of specialists is singularly focused on the development of innovative calcium and polymer compounds for surgical use. Based in Keele, UK with global operations across Europe, USA, Canada, Argentina, China and India, our products are now used in over 1 million procedures every year and sold in more than 100 countries around the world. https://www.biocomposites.com/

BONESUPPORT™ BONESUPPORT is the innovator of CERAMENT G with Gentamicin, the first and only FDA authorized combination antibiotic–eluting bone graft indicated for bone infection. As the first injectable combination antibiotic bone graft substitute, CERAMENT G can be delivered in a single–stage procedure to simultaneously support bone remodeling and locally elute Gentamicin to protect bone healing. It can help significantly reduce the recurrence of infection while improving patient outcomes and quality of life and reducing healthcare costs. The CERAMENT technology has the largest amount of pre–clinical and clinical data to prove bone remodeling and is the only bone graft substitute technology supported by a Level I randomized controlled trial. www.bonesupport.com

The mission of the Paley Foundation (West Palm Beach, Florida) is to educate and mentor orthopedic surgeons worldwide in the application of innovative medical techniques to assess, treat, and rehabilitate children and adults who suffer from rare and neglected bone diseases, limb deficiencies, and skeletal abnormalities. The Foundation supports four upcoming orthopedic courses:
Pediatric Foot & Ankle Deformities Course (November 14 & 15, 2025)
Congenital Limb Deficiencies & Deformities Live Surgery Course (January 19 - 23, 2026)
Orthopedic Management of Rare Conditions Conference (February 27 & 28, 2026)
Advanced Rehabilitation Techniques for Limb Lengthening & Deformity Correction (2026 TBD)
Proceeds from the sale of CFD: Congenital Femoral Deficiency, an orthopedic surgeon's systematic guide for the diagnosis and treatment of CFD in children and young adults are committed to supporting the Paley Foundation's efforts. Please visit: www.ThePaleyFoundation.org for more information.

Globus Medical, Inc. is a leading musculoskeletal technology company based in Audubon, PA. The company was founded in 2003 by an experienced group of engineers and business leaders who believed that significantly better patient outcomes in spine surgery were possible. Today Globus Medical is committed to creating products that enable surgeons to promote healing in patients with musculoskeletal disorders. https://www.globusmedical.com/

Insight Surgery has provided patient-specific Surgical Guides for over 1000 surgeries in the US and UK. Their FDA cleared platform helps surgeons plan complex cases with absolute precision and deliver Guides in as little as 5 working days.

International Limb Differences Network is a global network of orthopedic surgeons, researchers and allied healthcare professionals with a common goal to improve the health related quality of life of patients with limb differences.
https://www.limbnetwork.com/

The orthopaedics solutions of J&J MedTech provides one of the most comprehensive orthopaedics portfolios in the world that helps heal and restore movement for the millions of patients we serve.

Kyowa Kirin aims to discover and deliver novel medicines and treatments with life-changing value. As a Japan-based Global Specialty Pharmaceutical Company, we have invested in drug discovery and biotechnology innovation for more than 70 years and are currently working to engineer the next generation of antibodies and cell and gene therapies with the potential to help patients with high unmet medical needs, such as bone & mineral, intractable hematological diseases/hemato oncology, and rare diseases. A shared commitment to our values, to sustainable growth, and to making people smile unites us across the globe. Learn more about Kyowa Kirin at: https://www.kyowakirin.com.

MY01® At MY01, we are revolutionizing the management of limb perfusion injuries through our Continuous Perfusion Sensor Technology (CPST). By converting complex biological signals into real-time, actionable data, we empower healthcare professionals to make informed decisions, reduce variability in patient care, and enhance patient outcomes.

ORTHOFIX® The newly merged Orthofix–SeaSpine organization is a leading global spine and orthopedics company with a comprehensive portfolio of biologics, innovative spinal hardware, bone growth therapies, specialized orthopedic solutions and a leading surgical navigation system. Its products are distributed in approximately 68 countries worldwide. The company is headquartered in Lewisville, Texas and has primary offices in Carlsbad, CA, with a focus on spine and biologics product innovation and surgeon education, and Verona, Italy, with an emphasis on product innovation, production, and medical education for orthopedics. The combined company's global R&D, commercial and manufacturing footprint also includes facilities and offices in Irvine, CA, Toronto, Canada, Sunnyvale, CA, Wayne, PA, Olive Branch, MS, Maidenhead, UK, Munich, Germany, Paris, France and São Paulo, Brazil. To learn more, visit Orthofix.com.

OrthoPediatrics® Leading Innovation in Pediatric Orthopedics Founded in 2006, OrthoPediatrics is an orthopedic company focused exclusively on advancing the field of pediatric orthopedics. As such it has developed the most comprehensive product offering to the pediatric orthopedic market to improve the lives of children with orthopedic conditions. OrthoPediatrics currently markets 46 surgical systems that serve three of the largest categories within the pediatric orthopedic market. This product offering spans trauma and deformity, scoliosis, and sports medicine/other procedures. OrthoPediatrics' global sales organization is focused exclusively on pediatric orthopedics and distributes its products in the United States and over 70 countries outside the United States. For more information, please visit www.orthopediatrics.com.

Paragon 28® a ZIMMER BIOMET company Paragon 28, a Zimmer Biomet company, works relentlessly to advance the science behind foot & ankle surgery. We are passionate about blending different surgical philosophies from various global thought leaders to develop biomechanically and clinically relevant surgical solutions, we are committed to creating complete surgeon-centric systems, specialty instruments and next generation implants designed to solve real world issues faced by foot & ankle surgeons. From subchondral lesions to ankle reconstruction, we are constantly innovating our robust product portfolio to address forefoot, midfoot and hindfoot deficiencies, designed to drive efficiency and optimize patient care. Now, as part of Zimmer Biomet, the leader in musculoskeletal care, we are aligned in their Mission to alleviate pain and improve quality of life for patients around the world.

RESPONSE ORTHO Response Ortho is a global orthopedic trauma solutions manufacturer offering premium products created under its founding principles of innovation, excellence by design, and functional superiority.

Smith+Nephew prides itself on being a partner to the Limb Reconstruction surgeon and an innovator in circular fixation technology. We help you push the boundaries in limb restoration and allow your patients to rediscover the joy of Life Unlimited. Visit www.smith–nephew.com to learn about our products.

Stryker is one of the world's leading medical technology companies and together with our customers, we are driven to make healthcare better. The Company offers a diverse array of innovative products and services in Orthopaedics, Medical and Surgical, and Neurotechnology and Spine, which help improve patient and hospital outcomes. https://www.stryker.com/

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

Meeting Evaluation

The meeting evaluation is online. Please go to the following link and complete the evaluation by **Friday, August 1, 2025**. *Your responses are needed for CME credit to be valid.*

https://www.surveymonkey.com/r/LLRSAM2025

Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

Continuing Medical Education

This activity has been planned and implemented in accordance with the accreditation requirements and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of the American Academy of Orthopaedic Surgeons and the Limb Lengthening and Reconstruction Society. 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 9.5 AMA PRA Category 1 Credits™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Please join us next year!

35th Annual Scientific Meeting

Sofitel Golden Mile

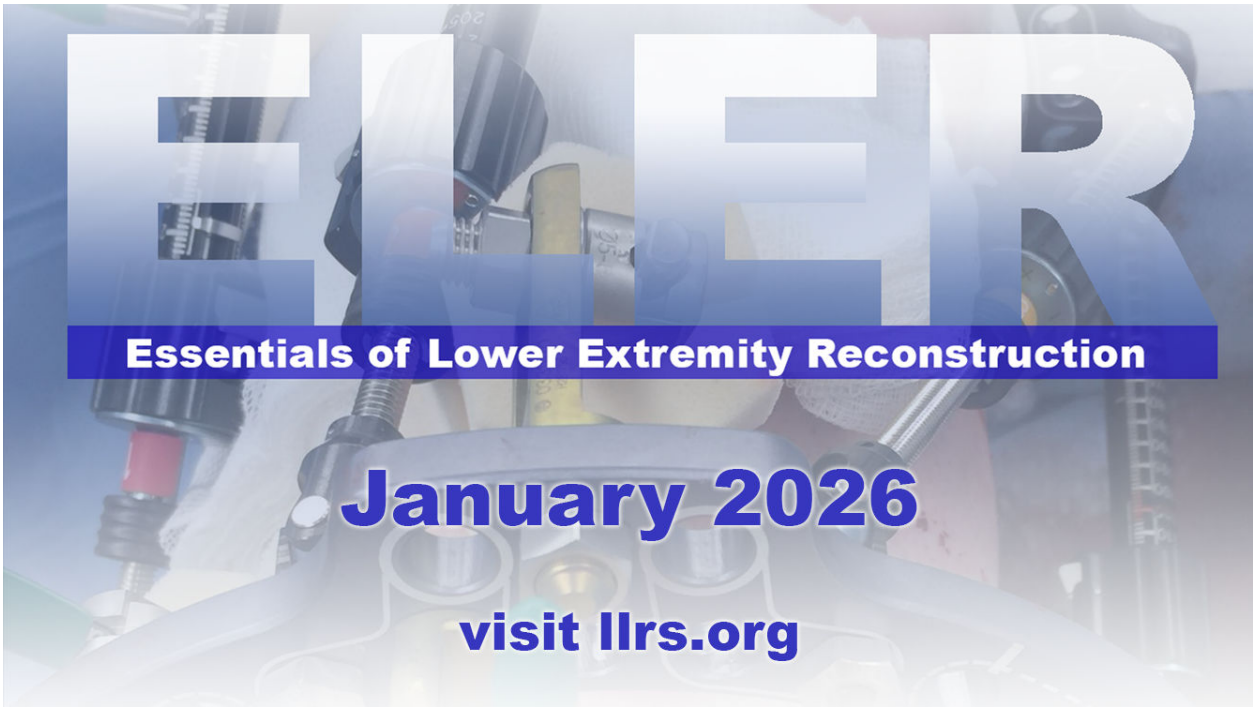
Montreal, Quebec, Canada

Please complete the evaluation online at

https://www.surveymonkey.com/r/LLRSAM2025

on or before **August 1, 2025.**


Save the Date!
35th Annual
Baltimore Limb Deformity Course
August 20–24, 2025
Four Seasons Hotel
Baltimore, Maryland, USA
www.DeformityCourse.com


ELER
Essentials of Lower Extremity Reconstruction
January 2026
visit llrs.org

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Disclosures

LLRS - 2025 Annual Meeting - Disclosure Report	
Member Name	Disclosure Summary
Al Muderis, Munjed MBCHB, FRACS, FRCS (Ortho)	Submitted on: 06/17/2024 Aesculap/B.Braun: Unpaid consultant Journal of Military and Veterans' Health: Editorial or governing board Medacta International SA: IP royalties Osseointegration International B.V.: Stock or stock Options Osseointegration International Pty Ltd: IP royalties; Paid consultant; Stock or stock Options Osseointegration International S.p.A: Stock or stock Options Permedica: Unpaid consultant Specifica Pty Ltd: Paid consultant World Journal of Orthopaedics: Editorial or governing board
Al Ramlawi, Akram	Submitted on: 10/9/2024 This individual reported nothing to disclose.
Alnasser, Abdulrhman MD	(This individual reported nothing to disclose); Submitted on: 09/28/2024
Alrajhi, Khaled MD	Submitted on: 5/21/2025 This individual reported nothing to disclose.
Assayag, Michael MD, FAAOS, FRCSC	Submitted on: 04/23/2024 Kyowa kirin: Paid presenter or speaker Nuvasive: Research support Orthopediatrics: Paid consultant
Babcock, Sharon MD, FAAOS	Submitted on: 04/09/2024 Smith & Nephew: Paid consultant
Bafor, Anirejuoritse MD, FACS	Submitted on: 5/20/2025 WishBone Medical Inc.: Type: Other Professional Activities Member of the Training Committee of the Limb Lengthening and Reconstruction Society of Nigeria (LLRSN): Type: Board of Directors or committee member Self

*a. All relevant financial relationships have been mitigated **Program Committee

Baldwin, Keith MD, FAAOS	Submitted on: 4/7/2025 OrthoPediatrics Corp.: Type: Other Professional Activities CORTICES Research Group- Board of Director: Type: Board of Directors or committee member Self Editorial Board - JCO; JBJS Reviews; JOT: Type: Editorial or governing board Self
Barre, Alyssa MD	Submitted on: 4/8/2025 This individual reported nothing to disclose.
Bashier, Mohammed	Submitted on: 5/30/2025 This individual reported nothing to disclose.
Bernstein, Mitchell MD, FAAOS**	Submitted on: 4/27/2025 restor3d, inc.: Type: Stock Option Orthofix Medical, Inc.: Type: Other Professional Activities DePuy Synthes Products, Inc.: Type: Other Professional Activities OrthoPediatrics Corp.: Type: Other Professional Activities Smith and Nephew: Type: Other Professional Activities NuVasive Specialized Orthopedics, Inc.: Type: Other Professional Activities Limb Lengthening and Reconstruction Society: Type: Board of Directors or committee member Self
Bess, Laura MD	Submitted on: 6/27/2025 This individual reported nothing to disclose.
Blair, James MD, FAAOS, FACS*	Submitted on: 4/12/2025 Smith & Nephew, Inc.: Type: Other Professional Activities Johnson & Johnson/Depuy Orthopedic: Type: Other Professional Activities Orthofix Medical, Inc.: Type: Other Professional Activities Stryker: Type: Other Professional Activities IlluminOss Medical, Inc.: Type: Other Professional Activities Integra LifeSciences Corporation: Type: Other Professional Activities Globus Medical, Inc.: Type: Other Professional Activities Limb Lengthening and Reconstruction Society - Member at Large: Type: Board of Directors or committee member Self
Bomar, James	Submitted on: 6/8/2025 This individual reported nothing to disclose.

*a. All relevant financial relationships have been mitigated **Program Committee

Bonilla, Kelsey MD	Submitted on: 6/11/2025 This individual reported nothing to disclose.
Bosshard, Sarah PhD	Submitted on: 5/8/2025 This individual reported nothing to disclose.
Bozzo, Isabella MD	Submitted on: 5/22/2025 This individual reported nothing to disclose.
Brooks, Benjamin	Submitted on: 5/29/2025 This individual reported nothing to disclose.
Brown, Michael BS	Submitted on: 5/22/2025 This individual reported nothing to disclose.
Mehraban Alvandi, Leila	Submitted on: 10/11/2024 This individual reported nothing to disclose.
Sanderson, Cody MD	Submitted on: 6/4/2025 This individual reported nothing to disclose.
Canitia, Emily NP	Submitted on: 10/10/2024 This individual reported nothing to disclose.
Casey, Virginia MD, FAAOS	Submitted on: 5/29/2025 This individual reported nothing to disclose.
Chalmers, Christen MD	(This individual reported nothing to disclose); Submitted on: 06/03/2024
Chandler, Calvin MD, MBA	Submitted on: 5/8/2025 This individual reported nothing to disclose.
Chao, Jessica BS	Submitted on: 10/9/2024 This individual reported nothing to disclose.
Chen, Andrew MD, MPH, FAAOS	(This individual reported nothing to disclose); Submitted on: 07/17/2024
Cherkashin, Alexander MD	Submitted on: 05/19/2024 Orthofix, Inc.: IP royalties; Paid consultant
Chhina, Harpreet PhD	Submitted on: 5/26/2025 This individual reported nothing to disclose.
Chintalapudi, Nainisha MD	Submitted on: 4/14/2025 This individual reported nothing to disclose.
Chruscinski, Rafael MD	Submitted on: 6/26/2025 This individual reported nothing to disclose.

*a. All relevant financial relationships have been mitigated **Program Committee

Cieremans, David DO, MS	Submitted on: 4/9/2025 This individual reported nothing to disclose.
Clasen, Pernille MD, DO, DC, DDS, DMD, DMed, DNP, DPM, DPT, DRPH, DVM, EdD, PHARMD, PhD, JD, SCD, MBA, MCH(ORTH)(UK)	Submitted on: 5/26/2025 This individual reported nothing to disclose.
Coleman, Nana MD	(This individual reported nothing to disclose); Submitted on: 04/24/2024
Contrucci, Sarah DO	Submitted on: 5/23/2025 This individual reported nothing to disclose.
Cooper, Anthony FRCS (Ortho)	Submitted on: 5/28/2025 OrthoPediatrics Corp.: Type: Other Professional Activities BC Children?s Hospital Foundation: Type: Other Professional Activities BC Children's Hospital Research Institute: Type: IP Royalties OrthoPediatrics Corp.: Type: IP Royalties McMaster University: Type: IP Royalties DePuy Synthes Products, Inc.: Type: IP Royalties Pediatric Orthopaedic Society of North America: Type: IP Royalties BC Children?s Hospital Foundation: Type: IP Royalties Canadian Pediatric Orthopaedic Society: Type: Board of Directors or committee member Self
Coufal, Sarah BS	Submitted on: 5/30/2025 This individual reported nothing to disclose.
Dahodwala, Taikhoom MS (ORTH)	Submitted on: 6/3/2025 This individual reported nothing to disclose.
Darsalim, Mohammad BA	Submitted on: 5/4/2025 This individual reported nothing to disclose.

Davidson, Richard MD, FAAOS	Submitted on: 04/23/2020 Abbott: Stock or stock Options Biomet: Paid consultant; Paid presenter or speaker Bristol-Myers Squibb: Stock or stock Options GlaxoSmithKline: Stock or stock Options Journal of Bone and Joint Surgery - American: Editorial or governing board Journal of Pediatric Orthopedics: Editorial or governing board Medsonics: Unpaid consultant Merck: Stock or stock Options Pfizer: Stock or stock Options Zimmer: IP royalties ZimmerHoldings Inc Com: Stock or stock Options
Davis, Jana MD, FAAOS	Submitted on: 05/06/2024 Smith & Nephew: Paid consultant
Dean, Robert MD	Submitted on: 6/8/2025 This individual reported nothing to disclose.
DeMaio, Emily MD	Submitted on: 5/11/2025 This individual reported nothing to disclose.
Diaz, David PhD	Submitted on: 5/5/2025 DePuy Synthes Products, Inc.: Type: Employment
Dubowy, Susan PA-C	Submitted on: 5/27/2025 This individual reported nothing to disclose.
Abdelaziz, Mohamed MD, MS, MBCHB	Submitted on: 5/27/2025 This individual reported nothing to disclose.
Elerson, Emily RN	(This individual reported nothing to disclose); Submitted on: 05/13/2024
Farnsworth, Christine MS	Submitted on: 5/14/2025 This individual reported nothing to disclose.
Feldman, David MD, FAAOS	Submitted on: 04/11/2024 Globus Medical: IP royalties; Paid consultant Medacta: IP royalties; Paid consultant orthopediatrics: IP royalties; Paid consultant
Feng, James MD	Submitted on: 6/2/2025 This individual reported nothing to disclose.

*a. All relevant financial relationships have been mitigated **Program Committee

Ferreri, Emily	Submitted on: 4/9/2025 This individual reported nothing to disclose.
Flanagan, Jill MD, FAAOS**	Submitted on: 5/24/2025 Orthofix Medical, Inc.: Type: Other Professional Activities OrthoPediatrics Corp.: Type: Other Professional Activities Limb Lengthening and Reconstruction Society, second vice president : Type: Board of Directors or committee member Self
Fragomen, Austin MD, FAAOS	Submitted on: 05/13/2024 Nuvasive: IP royalties; Paid consultant; Paid presenter or speaker Smith & Nephew: Paid consultant; Paid presenter or speaker Synthes: Paid consultant; Paid presenter or speaker
Franzone, Jeanne MD, FAAOS	Submitted on: 5/25/2025 OrthoPediatrics Corp.: Type: Other Professional Activities Committee Member, Limb Lengthening and Reconstruction Society, Pediatric Society of North America, Osteogenesis Imperfecta Foundation, International Society for Children's Bone Health: Type: Board of Directors or committee member Self Consultant Reviewer, Journal of Pediatric Orthopaedics (JPO): Type: Editorial or governing board Self
Frick, Steven MD	Submitted on: 5/29/2025 ABOS: Type: Fiduciary Officer Springer Science and Business media LLC: Type: Other Professional Activities Elsevier Publishing: Type: Other Professional Activities ABOS: Type: Board of Directors or committee member Self JBJS Reviews: Type: Editorial or governing board Self
Fridberg, Marie	Submitted on: 04/03/2024 DOS. Danish Orthopaedic Society: Board or committee member EFORT: Board or committee member IODA, International Orthopaedics Diversity Alliance: Board or committee member

*a. All relevant financial relationships have been mitigated **Program Committee

Frumberg, David MD, FAAOS	Submitted on: 5/13/2025 OrthoPediatrics Corp.: Type: Other Professional Activities Orthofix Medical, Inc.: Type: Other Professional Activities Kyowa Kirin, Inc.: Type: Other Professional Activities Ultragenyx Pharmaceutical Inc.: Type: Other Professional Activities Limb Lengthening and Reconstruction Society, American Academy for Cerebral Palsy and Developmental Medicine: Type: Board of Directors or committee member Self
Furdock, Ryan MD	Submitted on: 6/26/2025 This individual reported nothing to disclose.
Gehred, Alison	Submitted on: 5/23/2025 This individual reported nothing to disclose.
Ghaffari, Arash MD	Submitted on: 5/29/2025 This individual reported nothing to disclose.
Gibly, Romie MD, PhD, FAAOS	Submitted on: 4/13/2025 Cerapedics, Inc.: Type: IP Royalties BAXTER HEALTHCARE: Type: Other Professional Activities Guidepoint Global: Type: Other Professional Activities Pediatric Orthopaedic Society of North America: Type: IP Royalties
Gill, Corey MD, FAAOS	Submitted on: 5/27/2025 This individual reported nothing to disclose.
Gjonbalaj, Edina BS	Submitted on: 5/13/2025 This individual reported nothing to disclose.
Glassband, Zachary	Submitted on: 5/29/2025 This individual reported nothing to disclose.
Glatt, Vaida PhD	Submitted on: 5/19/2025 Current Institution Type: IP Royalties
Glennon, Alyssa BS	Submitted on: 6/26/2025 Materialise USA LLC: Type: Stock
Goodbody, Christine MD	(This individual reported nothing to disclose); Submitted on: 09/08/2024
Graham, Dillon	Submitted on: 10/15/2024 This individual reported nothing to disclose.
Hadley, Morgan MD	Submitted on: 3/6/2025 This individual reported nothing to disclose.

*a. All relevant financial relationships have been mitigated **Program Committee

Hanchar, Jonathan	Submitted on: 5/14/2025 This individual reported nothing to disclose.
Hariharan, Arun MD, MS	Submitted on: 4/9/2025 Globus Medical, Inc.: Type: Other Professional Activities highri: Type: Other Professional Activities Medtronic USA, Inc.: Type: Other Professional Activities Biedermann Motech, Inc.: Type: Other Professional Activities
Harrison, Noah MD, MSc	Submitted on: 4/9/2025 Type: IP Royalties American Board of Orthopaedic Surgery - Resident Advisory Panel Member: Type: Board of Directors or committee member Self
Hatfield, Danielle MS, NP	Submitted on: 10/10/2024 This individual reported nothing to disclose.
Haws, Brittany MD	Submitted on: 5/30/2025 This individual reported nothing to disclose.
Herge, Whitney PhD	Submitted on: 10/9/2024 This individual reported nothing to disclose.
Hernandez-Irizarry, Roberto MD, FAAOS	Submitted on: 5/15/2025 This individual reported nothing to disclose.
Herzenberg, John MD, FAAOS, FRCSC	Submitted on: 06/04/2024 DePuy Synthes: Other financial or material support Nuvasive: Unpaid consultant Orthofix, Inc.: Unpaid consultant Orthopediatrics: Unpaid consultant Smith & Nephew: IP royalties; Paid presenter or speaker Turner Imaging: Stock or stock Options
Hoellwarth, Jason MD*	Submitted on: 04/05/2024 Stryker: Paid consultant
Horn, Bernard MD, FAAOS	Submitted on: 6/11/2025 This individual reported nothing to disclose.
Horovitz, Ofir	Submitted on: 5/13/2025 This individual reported nothing to disclose.

*a. All relevant financial relationships have been mitigated **Program Committee

Howard, Kateland	Submitted on: 6/25/2025 This individual reported nothing to disclose.
Hsu, Joseph MD, FAAOS*	Submitted on: 05/06/2024 Austin Medical: Paid consultant Smith & Nephew: IP royalties; Paid consultant; Paid presenter or speaker Stryker: IP royalties; Paid consultant; Paid presenter or speaker
Huang, Dave	(This individual reported nothing to disclose); Submitted on: 06/02/2024
Hubbard, Elizabeth MD, FAAOS	Submitted on: 08/27/2024 Editorial Board: Editorial or governing board Journal of the Pediatric Orthopaedic Society of North America, Elsevier: Editorial or governing board Limb Lengthening and Reconstruction Society: Board or committee member Orthofix, Inc.: Unpaid consultant Pediatric Orthopaedic Society of North America: Board or committee member
Huser, Aaron DO	Submitted on: 10/25/2023 Biomarin: Paid presenter or speaker
Husum, Hans-Christen MD	(This individual reported nothing to disclose); Submitted on: 03/29/2024
Iobst, Christopher MD, FAAOS**	Submitted on: 10/9/2024 Smith and Nephew Orthopaedics: Type: Other Professional Activities OrthoPediatrics Corp.: Type: Other Professional Activities Globus Medical, Inc.: Type: Other Professional Activities Orthofix Medical, Inc.: Type: Other Professional Activities Limb Lengthening and Reconstruction Society : Type: Board of Directors or committee member Self Journal of Limb Lengthening and Reconstruction Limb Lengthening and Reconstruction Society : Type: Editorial or governing board Self
Jackson, Madeleine MD	Submitted on: 5/21/2025 This individual reported nothing to disclose.
Jaramillo, Diego	Submitted on: 5/29/2025 Pfizer: Type: Other Professional Activities American Academy of Radiology and Biomedical Imaging Research: Type: Board of Directors or committee member Self Radiology: Type: Editorial or governing board Self

*a. All relevant financial relationships have been mitigated **Program Committee

Jensen, Lili PhD, MSc, BSN	Submitted on: 6/10/2025 This individual reported nothing to disclose.
Jensen, Tina	Submitted on: 6/11/2025 This individual reported nothing to disclose.
Jodah, Riasoya	Submitted on: 6/28/2025 This individual reported nothing to disclose.
Kadhim, Muayad MD	Submitted on: 5/23/2025 This individual reported nothing to disclose.
Kahlon, Harsh	Submitted on: 5/27/2025 This individual reported nothing to disclose.
Kahn, Mani MD, MPH, FAAOS	Submitted on: 5/21/2025 Limb Lengthening and Reconstruction Society : Type: Other Professional Activities Orthopaedic Trauma Association (OTA) Disclosure Form: Type: Other Professional Activities Johnson and Johnson: Type: Other Professional Activities General Electric: Type: Other Professional Activities Orthopaedic trauma association and limb lengthening and reconstruction society committees and executive board: Type: Board of Directors or committee member Self
Kakulamarri, Shravya	Submitted on: 5/29/2025 This individual reported nothing to disclose.
KAMMEN, Bamidele MD	Submitted on: 5/21/2025 This individual reported nothing to disclose.
Kaszuba, Stephanie MD	Submitted on: 5/13/2025 This individual reported nothing to disclose.
Kelly, Nicholas BA	Submitted on: 6/1/2025 This individual reported nothing to disclose.
Kha, Stephanie MD	Submitted on: 4/15/2025 This individual reported nothing to disclose.
Klassen, Anne PhD	(This individual reported nothing to disclose); Submitted on: 04/05/2024
Kold, Søren MD, PhD	Submitted on: 5/28/2025 This individual reported nothing to disclose.
Kruse, Richard DO, FAAOS	Submitted on: 10/16/2024 This individual reported nothing to disclose.

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Kvist, Ola MD	Submitted on: 6/26/2025 This individual reported nothing to disclose.
Law, Jennifer	Submitted on: 5/23/2025 This individual reported nothing to disclose.
Leija, Natalia BS	Submitted on: 5/23/2025 This individual reported nothing to disclose.
Lesko, James PhD	Submitted on: 5/13/2025 Johnson and Johnson: Type: Employment
Liu, Raymond MD, FAAOS	Submitted on: 3/28/2025 Journal of Pediatric Orthopaedics: Type: Other Professional Activities Type: Other Intellectual Property Pediatric Orthopaedic Society of North America: Vice Chair, Evidence Based Medicine Committee / American Academy of Orthopaedic Surgeons: Member, Education Assessments and Examinations Committee : Type: Board of Directors or committee member Self Journal of Pediatric Orthopaedics: Deputy Editor, Hip and Lower Extremity: Type: Editorial or governing board Self
Lundblad, Henrik MD	Submitted on: 5/23/2025 This individual reported nothing to disclose.
Luzzi, Richard MD, MSc	Submitted on: 6/6/2025 This individual reported nothing to disclose.
Mahapatra, Harshit	Submitted on: 5/31/2025 This individual reported nothing to disclose.

*a. All relevant financial relationships have been mitigated **Program Committee

Marecek, Geoffrey MD, FAAOS	Submitted on: 4/9/2025 Zimmer Biomet Holdings, Inc.: Type: Other Professional Activities AO Foundation: Type: Other Professional Activities AO Foundation: Type: Fiduciary Officer Globus Medical, Inc.: Type: Other Professional Activities restor3d, inc.: Type: Stock Option BoneSupport AB: Type: Other Professional Activities Siemens: Type: Other Professional Activities Johnson & Johnson/Depuy Orthopedic: Type: Other Professional Activities AO Foundation: Type: IP Royalties Orthofix Medical, Inc.: Type: Other Professional Activities Type: Other Intellectual Property Type: Other Intellectual Property AO North America Research Committee: Type: Board of Directors or committee member Self AAOS Comprehensive Orthopaedic Review 4: Type: Editorial or governing board Self
Marquez, Guillermo MD	Submitted on: 5/13/2025 This individual reported nothing to disclose.
McBride-Gagyi, Sarah PhD	Submitted on: 5/30/2025 U.S. Department of Veterans Affairs: Type: Other Professional Activities Orthopaedic Research Society: Type: Other Professional Activities Both Current and Former institution Type: IP Royalties Previous Institution Type: IP Royalties Ohio State University: Type: Employment Orthopaedic Research Society: Type: Other Professional Activities National Institutes of Health: Type: Other Professional Activities Orthopaedic Research Society 2024-2026 - Award and Recognition Committee 2024 - 2026 - Research and Education Officer for International Section of Fracture Repair 2022-2024 - Co-chair for Annual Meeting Bone Tract: Type: Board of Directors or committee member Self Journal of Orthopaedic Research, editorial board: Type: Editorial or governing board Self

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McCarthy, Alicia NP	Submitted on: 6/27/2025 This individual reported nothing to disclose.
McClure, Philip MD, FAAOS	Submitted on: 10/9/2024 Orthofix Medical, Inc.: Type: Other Professional Activities OrthoPediatrics Corp.: Type: Other Professional Activities WishBone Medical Inc.: Type: Other Professional Activities NuVasive Specialized Orthopedics, Inc.: Type: Other Professional Activities
Metzger, Melodie PhD	Submitted on: 06/08/2024 Arthrex, Inc: Research support
Miller, Anna MD, FAAOS, FACS	Submitted on: 4/9/2025 Smith and Nephew: Type: Other Professional Activities CustomSurg: Type: Fiduciary Officer Board: OTA, ACS, AOA; Committee chair AAOS: Type: Board of Directors or committee member Self Editorial Board: JOT, Orthopedics Today, OTA FractureBook: Type: Editorial or governing board Self
Mir, Hassan MD, MBA, FAAOS, FACS*	Submitted on: 06/09/2024 AAOS BOS Representative from OTA: Board or committee member Abyrx: Stock or stock Options ACS Committee on Trauma: Board or committee member Acumed, LLC: Paid consultant American Orthopaedic Association: Board or committee member AO Trauma North America: Research support JAAOS Consultant Reviewer: Editorial or governing board JBJS Consultant Reviewer: Editorial or governing board Journal of Orthopaedic Trauma Associate Editor: Editorial or governing board OrthoGrid: Stock or stock Options OTA BOD: Board or committee member OTA CFO: Board or committee member OTA International Digital Editor: Editorial or governing board Smith & Nephew: Paid consultant Stryker: Paid consultant Synthes: Paid consultant

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Moon, Tyler MD	Submitted on: 10/10/2024 This individual reported nothing to disclose.
Mosfeldt, Mathias MD, PhD	Submitted on: 5/26/2025 This individual reported nothing to disclose.
Munoz, Andrea BS	Submitted on: 5/13/2025 This individual reported nothing to disclose.
Natoli, Roman MD, PhD, FAAOS	Submitted on: 10/9/2024 This individual reported nothing to disclose.
Niese, Brad	Submitted on: 5/19/2025 This individual reported nothing to disclose.
Nocella, Kimberly MSN, RN	Submitted on: 5/5/2025 This individual reported nothing to disclose.
Nossov, Sarah MD, FAAOS	Submitted on: 11/1/2024 BioMarin Pharmaceutical Inc.: Type: Other Professional Activities LLRS - membership committee - committee member POSNA - history committee - past chair: Type: Board of Directors or committee member Self
Obremskey, William MD, MPH, FAAOS	Submitted on: 4/8/2025 U.S. Department of Defense: Type: IP Royalties Orthopedic Trauma Association: Type: Other Professional Activities Orthopdic Trauma Association: Type: Board of Directors or committee member Self
Otterburn, David MD	Submitted on: 6/4/2025 This individual reported nothing to disclose.
Over, Daniel BS	Submitted on: 5/13/2025 This individual reported nothing to disclose.
Paley, Dror MD, FAAOS, FRCSC	Submitted on: 04/11/2024 Nuvasive: IP royalties; Paid consultant Orthopediatrics: IP royalties

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Patterson, Joseph MD, FAAOS, FACS*	Submitted on: 10/05/2024 AOTrauma North America: Board or committee member; Research support Bodycad: IP royalties; Paid consultant European Journal of Orthopaedic Surgery and Traumatology: Editorial or governing board Globus Medical: Paid consultant Johnson & Johnson: Paid consultant Journal of Orthopaedic Trauma: Editorial or governing board Orthopaedic Trauma Association: Board or committee member; Research support Stryker: Paid consultant
Pepic, Lejla BS	Submitted on: 6/1/2025 This individual reported nothing to disclose.
Perdomo, Camilo MD	Submitted on: 5/23/2025 This individual reported nothing to disclose.
Podeszwa, David MD, FAAOS	Submitted on: 09/30/2024 Limb Lengthening and Reconstruction Society: Board or committee member Orthofix, Inc.: Paid consultant
Pousett, Brittany	Submitted on: 6/2/2025 Canadian Institutes of Health Research: Type: IP Royalties Barber Prosthetics Clinic: Type: Employment Board Member - International Society of Prosthetics & Orthotics Canada Committee Member (chair) - Prosthetics & Orthotics Joint Research Council : Type: Board of Directors or committee member Self
Raja, Neelufar BA	(This individual reported nothing to disclose); Submitted on: 04/02/2024
Reif, Taylor MD, FAAOS	Submitted on: 4/14/2025 Bodycad USA Corp: Type: Other Professional Activities OrthoPediatrics Corp.: Type: Other Professional Activities
Reyes, Alexandra BS	Submitted on: 5/23/2025 This individual reported nothing to disclose.
Rider, Danielle MD	Submitted on: 5/9/2025 This individual reported nothing to disclose.

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Rivera, Jessica MD, PhD, FAAOS	Submitted on: 4/23/2025 Orthopaedic Research Society: Type: Other Professional Activities American Academy of Orthopaedic Surgeons: Type: Other Professional Activities Limb Lengthening and Reconstruction Society: Type: Board of Directors or committee member Self Journal of Limb Lengthening and Reconstruction: Type: Editorial or governing board Self
Robilotti, Elizabeth	(This individual reported nothing to disclose); Submitted on: 05/06/2024
Roche, Morgan BS	Submitted on: 5/28/2025 This individual reported nothing to disclose.
Rosenblatt, Joseph DO, FAAOS	Submitted on: 4/11/2025 Johnson & Johnson/Depuy Orthopedic: Type: Other Professional Activities Philadelphia Orthopedic Society, past president: Type: Board of Directors or committee member Self
Rozbruch, S MD, FAAOS	Submitted on: 6/7/2025 ALM Ortho: Type: Stock Type: Other Intellectual Property ALM Ortho: Type: Stock Option Nuvasive Specialty orthopedics Type: IP Royalties Kyniska Robotics: Type: Stock Option
Ryan, Justin PhD, MBA	Submitted on: 4/11/2025 Radiological Society of North America: Type: Other Professional Activities Digital Imaging and Communications in Medicine: Type: Other Professional Activities DICOM WG17, RSNA 3D SIG: Type: Board of Directors or committee member Self 3D Printing in Medicine Journal: Type: Editorial or governing board Self
Sabatini, Coleen MD, MPH, FAAOS	Submitted on: 04/05/2024 AAOS: Board or committee member American Orthopaedic Association: Board or committee member J. Robert Gladden Society: Board or committee member MiracleFeet Medical Advisory Board: Board or committee member Pediatric Orthopaedic Society of North America: Board or committee member Ruth Jackson Orthopaedic Society: Board or committee member

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Sabharwal, Sanjeev MD, MPH, FAAOS	Submitted on: 04/05/2024 Journal of Bone and Joint Surgery - American: Editorial or governing board; Publishing royalties, financial or material support Journal of Limb Lengthening and Reconstruction: Editorial or governing board Springer: Publishing royalties, financial or material support
Sachwani, Numera	Submitted on: 6/30/2025 This individual reported nothing to disclose.
Samchukov, Mikhail MD	Submitted on: 05/14/2024 Orthofix, Inc.: IP royalties; Paid consultant
Samuel, Zachariah BS	(This individual reported nothing to disclose); Submitted on: 09/03/2024
Sang, Luke BS	Submitted on: 4/16/2025 This individual reported nothing to disclose.
Santamaria, Gabriel BA	Submitted on: 10/31/2024 This individual reported nothing to disclose.
Sborov, Katherine MD	Submitted on: 5/22/2025 This individual reported nothing to disclose.
Schmitz, Matthew MD, FAAOS	Submitted on: 4/8/2025 Type: Other Intellectual Property JBJS: Type: Employment American Orthopaedic Association: Type: Fiduciary Officer American Orthopaedic Association Board Member; International Orthopaedic Diversity Alliance - President: Type: Board of Directors or committee member Self JBJS Editorial Board: Type: Editorial or governing board Self
Seymour, Rachel PhD	Submitted on: 06/03/2024 Orthopaedic Trauma Association: Board or committee member
Shah, Suken MD, FAAOS*	Submitted on: 11/16/2024 Type: Other Intellectual Property Setting Scollosis Straight Foundation: Type: Fiduciary Officer DePuy Synthes Spine: Type: Other Professional Activities Scoliosis Research Society: Type: Fiduciary Officer Stryker/K2M Type: IP Royalties Scoliosis Research Society: Type: Board of Directors or committee member Self

*a. All relevant financial relationships have been mitigated **Program Committee

Sharkey, Melinda MD, FAAOS	Submitted on: 10/24/2023 Pediatric Orthopaedic Society of North America: Board or committee member
Sharma, Mihir BS	Submitted on: 5/23/2025 This individual reported nothing to disclose.
Shenoy, Devika BS	Submitted on: 4/18/2025 This individual reported nothing to disclose.
Sieberer, Johannes MSc	Submitted on: 10/10/2024 This individual reported nothing to disclose.
Singh, Sirjanhar MD	Submitted on: 5/13/2025 This individual reported nothing to disclose.
Souder, Christopher MD, FAAOS	Submitted on: 6/3/2025 OrthoPediatrics Corp.: Type: Other Professional Activities POSNA QSVI trauma committee: Type: Board of Directors or committee member Self
Strub, Daryn BA	Submitted on: 5/13/2025 This individual reported nothing to disclose.
Suh, Nina MD, FAAOS	Submitted on: 10/17/2024 This individual reported nothing to disclose.
Syzdek, Karen - STAFF**	Submitted on: 4/8/2025
Swarup, Ishaan MD, FAAOS	This individual reported nothing to disclose.
Thompson, Daniel MS	(This individual reported nothing to disclose); Submitted on: 06/14/2024
Thomsen, Trine PhD	Submitted on: 6/8/2025 This individual reported nothing to disclose.
Todi, Niket MD	Submitted on: 6/9/2025 This individual reported nothing to disclose.
Turner, Lauren BS	Submitted on: 5/22/2025 This individual reported nothing to disclose.
Vasavada, Kinjal	Submitted on: 5/28/2025 This individual reported nothing to disclose.
Wahle, Charlotte BA	Submitted on: 4/9/2025 This individual reported nothing to disclose.
Wallace, Stephen MD	Submitted on: 4/25/2025 DePuy Synthes Products, Inc.: Type: Other Professional Activities Globus Medical, Inc.: Type: Other Professional Activities
Warner, Meredith MD, MBA, FAAOS	Submitted on: 12/22/2023 extremity medical: Paid consultant
Wassell, Meghan	Submitted on: 5/23/2025 This individual reported nothing to disclose.
Williams, Natalie BS	Submitted on: 5/27/2025 This individual reported nothing to disclose.
WU, ALEX	Submitted on: 5/21/2025 Johnson & Johnson/Depuy Orthopedic: Type: Employment
Yancey, Marlee BA	Submitted on: 5/27/2025 This individual reported nothing to disclose.
Yawman, Jonathan MD	(This individual reported nothing to disclose); Submitted on: 06/04/2024
Yong, Bicheng	Submitted on: 5/20/2025 This individual reported nothing to disclose.
Yu, Ziqing MS	(This individual reported nothing to disclose); Submitted on: 05/29/2024

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Limb Lengthening and Reconstruction Society

Association for the Study and Application of the Methods of Ilizarov–North America

Agenda

Friday, July 18, 2025

6:30–7:15 a.m.	Wellness Activity: Walk with Drs. Iobst and Nossov* – leave from hotel lobby
6:30–7:15 a.m.	Wellness Activity: 5K Run with Dr. Flanagan* – leave from hotel lobby
6:30–7:15 a.m.	Wellness Activity: Morning Yoga* – *pre–registration before 6/20 required* The Underground Spa on Lower Level (LL) of hotel
7:00 a.m.	Meeting Registration/Check–In Opens
7:15–8:00 a.m.	Continental Breakfast – The Stenton
7:15–8:00 a.m.	**Visit Corporate Partners*** – Ballroom Foyer & Mount Vernon
8:00–8:04 a.m.	Welcome/Introduction/Disclosure* – Ballroom *Christopher A. Iobst, MD*
8:05–8:44 a.m.	**Session I: Trauma I** Moderator: James A. Blair, MD
8:05–8:10 a.m.	Plate–Tensioned Nail for Repair of Femoral Nonunion after Failed Lengthening or Fracture Repair – *Joseph T. Patterson, MD*
8:11–8:16 a.m.	Three–Dimensional Virtual Modeling for Lower Limb Deformity Correction over Intramedullary Nail – *Roy Gigi, MD*
8:17–8:22 a.m.	Higher ASA Score Associated with Complications and Mortality Following Nonunion Surgery – *Morgan Roche, BS*
8:23–8:28 a.m.	Is it Time to Rethink Our Understanding of Contralateral Femoral Version? *Alyssa Barré, MD*
8:29–8:34 a.m.	Healing Wounds: Early Experience with Transverse Tibial Transport *Jessica C. Rivera, MD, PhD*
8:34–8:44 a.m.	Discussion
8:45–9:24 a.m.	**Session II: Pediatrics I** Moderator: Elizabeth Hubbard, MD
8:45–8:50 a.m.	Comparative Analysis of Limb Lengthening Complications in Children Aged 5 to 8 Versus Other Pediatric Age Groups – *Philip K. McClure, MD*

**No CME awarded*

8:51–8:56 a.m.	Threaded Non–Telescopic Rods Demonstrate Less Rod Prominence and Migration than Non–Threaded Non–Telescopic Rods in Patients with Osteogenesis Imperfecta: A Case–Control Study – *Jeanne M. Franzone, MD*
8:57–9:02 a.m.	Relative Closure of Growth Plates in the Upper and Lower Extremity Using Serial Radiographic Collection – *Marlee R. Yancey, BA*
9:03–9:08 a.m.	Acute Knee Flexion Contracture Correction in Patients with Arthrogryposis and Failed Distal Femoral Osteotomies – *Sarah Nossov, MD*
9:09–9:14 a.m.	Distal Femur Extension Osteotomy for Neuromuscular Knee Flexion Contracture: A Novel Technique Using Intramedullary Fixation *Stephanie Kaszuba, MD*
9:15–9:24 a.m.	Discussion
9:25–9:45 a.m.	Wellness Lecture – *Nana Coleman, MD, EdM*
9:46–9:50 a.m.	Wellness Lecture Discussion
9:51–10:30 a.m.	**Session III: Basic Science** Moderator: Jessica C. Rivera, MD, PhD
9:51–9:56 a.m.	Comparison of Compressive Forces Generated Between Standard and Magnetic Compression Nails – *Megan Audet, MD*
9:57–10:02 a.m.	The Neuromuscular Knee Displays Unique Rotatory Tibiofemoral Pathoanatomy – *Kateland Howard*
10:03–10:08 a.m.	Performance Comparison of Medical and Non–medical Wire Saw Designs for Surgical Bone Cutting – *Christopher A. Iobst, MD*
10:09–10:14 a.m.	Digital Monitoring of Patients Undergoing Orthopedic Deformity Correction: Feasibility and Patient Acceptability *Pernille Damborg Clasen, Research Nurse*
10:15–10:20 a.m.	The Effect of Closing Wedge Osteotomy on Leg Length Discrepancy: An Evaluation using Three–Dimensional Virtual Modeling – *Roy Gigi, MD*
10:21–10:30 a.m.	Discussion
10:31–10:50 a.m.	Wellness Break – The Stenton, Ballroom Foyer & Mount Vernon **Visit Corporate Partners***
10:51–11:30 a.m.	**Session IV: Trauma II** Moderator: Stephen M. Quinnan, MD
10:51–10:56 a.m.	Strain Reduction Lag Screws as Adjunct Fixation in Recalcitrant Tibial Nonunions – *Khaled Alrajhi, MD*

10:57–11:02 a.m.	Characteristics and Anatomical Location of Infected Pin–Sites *Marie Fridberg, MD, PhD*
11:03–11:08 a.m.	Differences Between Treatment Course Among Aseptic and Septic Nonunions and Malunions – *Mihir Sharma, BS*
11:09–11:14 a.m.	A Review of Medullary Based Bone Transport – *Carol Lee, MD*
11:15–11:20 a.m.	Femur Deformity Correction Using an Intramedullary Nail *Sarah Hebert–Seropian, MD*
11:20–11:30 a.m.	Discussion
11:31–12:10 p.m.	**Session V: Pediatrics II** Moderator: L. Reid Nichols, MD
11:31–11:36 a.m.	Congenital Pseudarthrosis of the Tibia: Is Pharmacological Adjuvant Therapy Imperative for Bone Healing in X–Union? – *Richard Luzzi, MD*
11:37–11:42 a.m.	Diffusion Tensor Imaging of the Distal Tibia and Fibula as a Marker of Skeletal Growth in Pediatric Patients: A Preliminary Experience *Camilo Perdomo, MD*
11:43–11:48 a.m.	So Many Surgeries: Can we Minimize the Number of Surgeries Performed for Deformity Correction in Severe Early–Onset Blount Disease? *Melinda Sharkey, MD*
11:49–11:54 a.m.	Early–Onset Blount Disease: Can We Predict Spontaneous Resolution? *Melinda Sharkey, MD*
11:55–12:00 p.m.	Predicting Success of Growth Modulation Surgery in Late Onset Tibia Vara (LOTV) – *Jill C. Flanagan, MD*
12:00–12:10 p.m.	Discussion
12:11–1:00 p.m.	Lunch – pick up Boxed Lunch in The Stenton **Visit Corporate Partners*** – Ballroom Foyer & Mount Vernon
1:01–1:50 p.m.	**Session VI: Award Nominated Papers I** Moderator: Mitchell Bernstein, MD
1:01–1:07 p.m.	Quantifying Proximal Tibial Physeal Injury in Rigid Intramedullary Nailing in Adolescent Patients – *Stephanie Kha, MD*
1:08–1:14 p.m.	Harnessing the Power of Nature: mRNA–Activated Biomimetic Hematoma Scaffold for Regeneration of Volumetric Muscle Loss – *Vaida Glatt, PhD*
1:15–1:21 p.m.	Normative Proximal Tibial Morphology Through Childhood and Implication for Deformity Analysis and Correction – *Emily DeMaio, MD*

**No CME awarded*

1:22–1:28 p.m.	Can the Addition of a 3D–Painted Bone Scaffold Accelerate the Maturation of Regenerate Bone During Distraction Osteogenesis in a Lapine Model? A Pilot Study – *Christopher A. Iobst, MD*
1:29–1:35 p.m.	Effect of Distraction Osteogenesis on Body Weight – An Experimental Study in a Lapine Model – *Anirejuoritse Bafor, MD*
1:36–1:50 p.m.	Discussion
1:51–1:55 p.m.	Alessandro Codivilla Guest Speaker Introduction
1:55–2:40 p.m.	**Alessandro Codivilla Guest Speaker*** Achieving Excellence *Blake Leeper* 2–time Paralympian; 2–time Paralympic Medalist
2:41–2:46 p.m.	Discussion
2:47–3:07 p.m.	Wellness Break – The Stenton, Ballroom Foyer & Mount Vernon **Visit Corporate Partners***
3:08–3:23 p.m.	**Traveling Fellowship Presentation** Introduction by Jaclyn F. Hill, MD *Caleb Gottlich, MD* *Saad Malik, MD* *Mike Russell, MD* *Ashley Startzman, MD* *Bicheng Yong, MD*
3:24–3:29 p.m.	LLRS Opportunity in Malawi* – *Mike Russell, MD*
3:30–4:15 p.m.	**Session VII: Award Nominated Papers II** Moderator: Jill C. Flanagan, MD
3:30–3:36 p.m.	Compounding Pulleys: Automated Multifocal Cable Bone Transport for Segmental Tibial Defects Using a Single Head Unit *Roberto Hernandez–Irizarry, MD*
3:37–3:43 p.m.	Comparative Outcomes of 8.5mm Intramedullary Nails versus Extramedullary Constructs for Femoral Lengthening in Pediatric Patients *Philip K. McClure, MD*
3:44–3:50 p.m.	To Correct or Overcorrect – That is the Question: Rates of Deformity Recurrence in Surgically Treated Early–Onset Blount Disease *Eduardo Valero–Moreno, MD*
3:51–3:57 p.m.	Treatment Outcomes Following Retrograde Femoral Extramedullary Lengthening Using an Internal Lengthening Nail – *Christopher A. Iobst, MD*

3:58–4:04 p.m.	Is there a Negative Correlation between Screw Length and Correction Rate via Guided Growth? A Retrospective Study of 138 African Limbs with Genu Varum – *Bicheng Yong, MD*
4:05–4:15 p.m.	Discussion
4:16–5:00 p.m.	Business Meeting* – **LLRS Members only**
6:30–8:30 p.m.	The President's Reception* – *ticket required* Barnes Foundation Museum of Art

Saturday, July 19, 2025

6:30–7:15 a.m.	Wellness Activity: 5K Run with Dr. Flanagan* – leave from hotel lobby
6:30–7:15 a.m.	Wellness Activity: Morning Yoga* – *pre–registration before 6/20 required* The Underground Spa on Lower Level (LL) of hotel
7:15 a.m.	Meeting Registration/Check–In Opens
7:15–8:00 a.m.	Continental Breakfast – The Stenton
7:15–8:00 a.m.	**Visit Corporate Partners*** – Ballroom Foyer & Mount Vernon
8:00–8:05 a.m.	Announcements – Ballroom
8:06–8:45 a.m.	**Session VIII: Patient Reported Outcomes** Moderator: Anthony Cooper, MD
8:06–8:11 a.m.	The Limb Lengthening and Reconstruction Society AIM Index: Correlations with Patient–Reported Outcome Measures in Pediatric Patients with Lower Limb Differences – *Luke Sang, BS*
8:12–8:17 a.m.	Correction of Femoral Rotational Malalignment with Intramedullary Nailing: A Retrospective Review of PROMs and Complications *Sarah Hebert–Seropian, MD*
8:18–8:23 a.m.	Role of Psychological Resiliency in Predicting Pediatric Limb Lengthening and Reconstruction Outcomes – *Whitney M. Herge, PhD*
8:24–8:29 a.m.	Comparison of Patient– and Parent–Reported Outcome Measures in Pediatric Limb Deformity Patients as Assessed by the LD–SRS *Marlee R. Yancey, BA*
8:30–8:35 a.m.	Impact of Limb Deformity Correction on Pediatric Quality of Life as Assessed by the LD–EOSQ and LD–SRS Patient–Reported Outcome Measures *Marlee R. Yancey, BA*
8:36–8:45 a.m.	Discussion

8:46–9:10 a.m.	**Special Guest Lecture** Generative Artificial Intelligence in Orthopedics *Alexander Cherkashin, MD*
9:11–9:50 a.m.	**Session IX: Limb Lengthening I** Moderator: David A. Podeszwa, MD
9:11–9:16 a.m.	The Impact of Multiple Limb Lengthening Procedures: A Single–Center Retrospective Study – *Akram Al Ramlawi, MD*
9:17–9:22 a.m.	Information Transparency for Elective Stature Lengthening Surgery: A Secret–Shopper Study – *Sanjeev Sabharwal, MD*
9:23–9:28 a.m.	Is It Safe to Drive During Femoral Limb Lengthening? A Prospective Study of Brake Reaction Performance – *Akram Al Ramlawi, MD*
9:29–9:34 a.m.	Humeral Lengthening in Patients with Achondroplasia: Clinical Results and Complications of Intramedullary Nailing and External Fixation *Michael W. Brown, BS*
9:35–9:40 a.m.	General Population Perceptions on Stature Lengthening – *Vivek Nair, MD*
9:41–9:50 a.m.	Discussion
9:51–9:55 a.m.	Presidential Guest Speaker Introduction
9:55–10:40 a.m.	**Presidential Guest Speaker** Ilizarov Method of Surgical Manipulation with Bone Length, Shape, and Structure *Mikhail Samchukov, MD*
10:41–10:45 a.m.	Presidential Guest Speaker Discussion
10:46–11:05 a.m.	Wellness Break – The Stenton, Ballroom Foyer & Mount Vernon **Visit Corporate Partners***
11:06–11:39 a.m.	**Session X: Osseointegration I** Moderator: Lee Zuckerman, MD
11:06–11:11 a.m.	Primary Amputation with Osseointegration Versus Osseointegration for Existing Amputation – *S. Robert Rozbruch, MD*
11:12 –11:17 a.m.	Transcutaneous Osseointegration for Adults whose Amputations were Performed During Childhood – *Taylor J. Reif, MD*
11:18–11:23 a.m.	Press–fit Osseointegration for Patients with Short Residual Bone *Mohamed Abdelaziz Elghazy, MD*
11:24–11:29 a.m.	Medium–term Outcomes of Transtibial Osseointegration in Association with Total Knee Replacement – *Munjed Al Muderis, MD*

11:30–11:39 a.m.	Discussion
11:40–12:10 p.m.	**Session XI: Limb Lengthening II** Moderator: Harold J. P. van Bosse, MD
11:40–11:45 a.m.	Outcomes Following Sequential Internal Lengthening of Long Bones: A Case Series – *Anirejuoritse Bafor, MD*
11:46–11:51 a.m.	Complication Rates in Cosmetic Bilateral Femoral Lengthening Using Intramedullary Lengthening Nails – *Akram Al Ramlawi, MD*
11:52–11:57 a.m.	A Comparison of Automated and Manual Strut Adjustment Systems for Circular Frame Correction of Limb Deformity in Pediatric and Adolescent Patients – *David Cieremans, DO, MS*
11:58–12:03 p.m.	Gradual Distalization of Chronic High Dislocation of the Hip with Motorized Nail Before Arthroplasty in Anatomical Position – A Case Series *Mathias Mosfeldt, MD, PhD*
12:04–12:10 p.m.	Discussion
12:11–12:31 p.m.	**Deborah F. Stanitski LLRS Diversity Presentation** A Culture in LLRS Where Everyone can Thrive and Develop *Marie Fridberg, MD, PhD*
12:32–12:55 p.m.	**Session XII: Osseointegration II** Moderator: David B. Frumberg, MD
12:32–12:37 p.m.	Safety and Early Experience of Osseointegration Limb Replacement with Custom–Fit Implants – *S. Robert Rozbruch, MD*
12:38–12:43 p.m.	Femur And Tibia Press–Fit Osseointegration – A Comparison of Safety and Outcomes – *Zachary Glassband, BA*
12:44–12:49 p.m.	Effect of BMI and Muscle Area Ratio on Complication Rate after Lower Extremity Osseointegration – *Mohamed Abdelaziz Elghazy, MD*
12:50–12:55 p.m.	Discussion
12:56–1:00 p.m.	Inaugural Hall of Fame Induction Introduction
1:00–1:30 p.m.	**Inaugural Hall of Fame Induction*** Stuart A. Green, MD John E. Herzenberg, MD – Introduced by Philip K. McClure, MD Dror Paley, MD – Introduced by S. Robert Rozbruch, MD
1:31–2:00 p.m.	President's Remarks and Introduction of 2025–2026 President* *Christopher A. Iobst, MD* and *Mitchell Bernstein, MD*

**No CME awarded*

Session I:

Trauma I

James A. Blair, MD, Moderator

Plate−Tensioned Nail for Repair of Femoral Nonunion after Failed Lengthening or Fracture Repair

Joseph T. Patterson, MD
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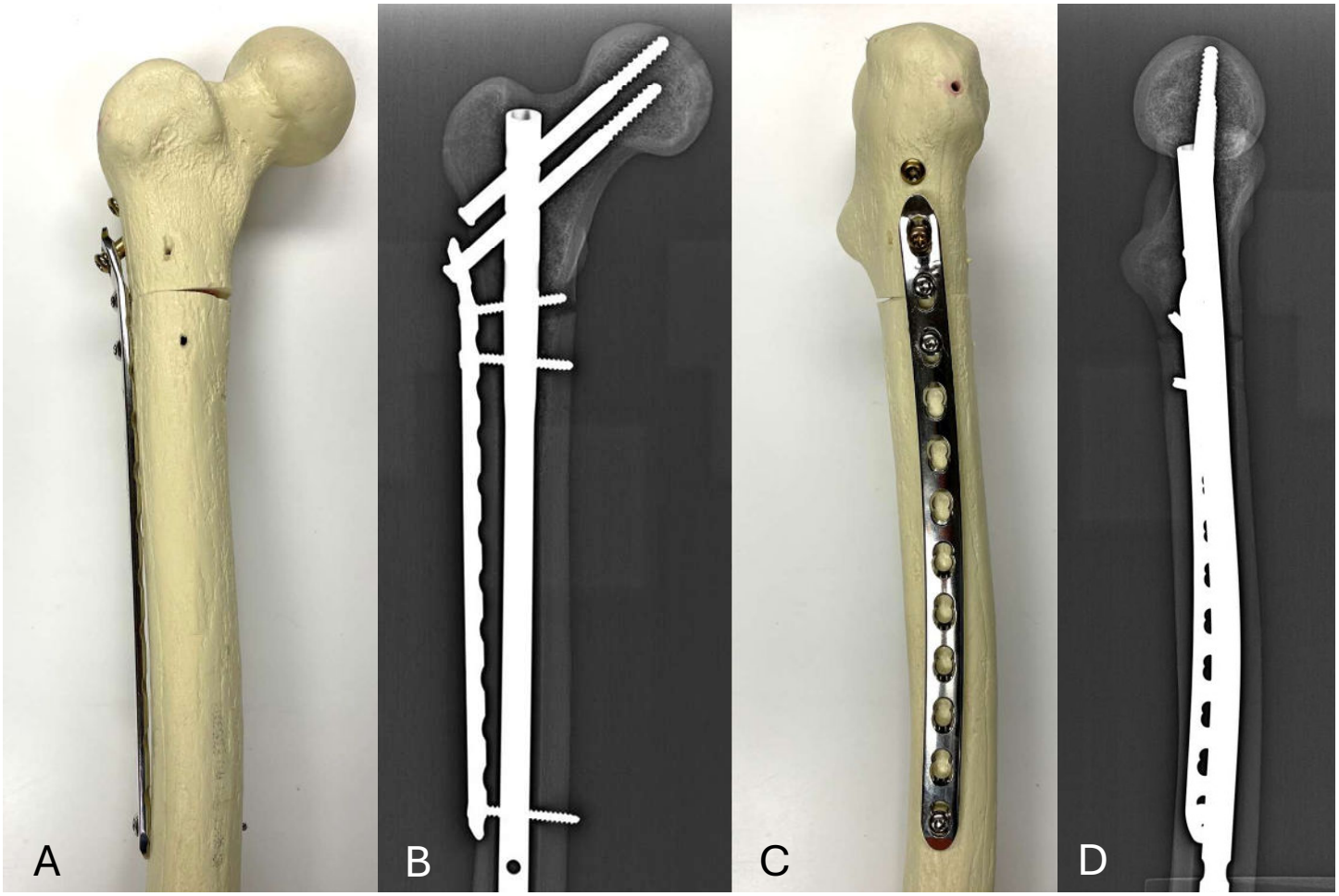
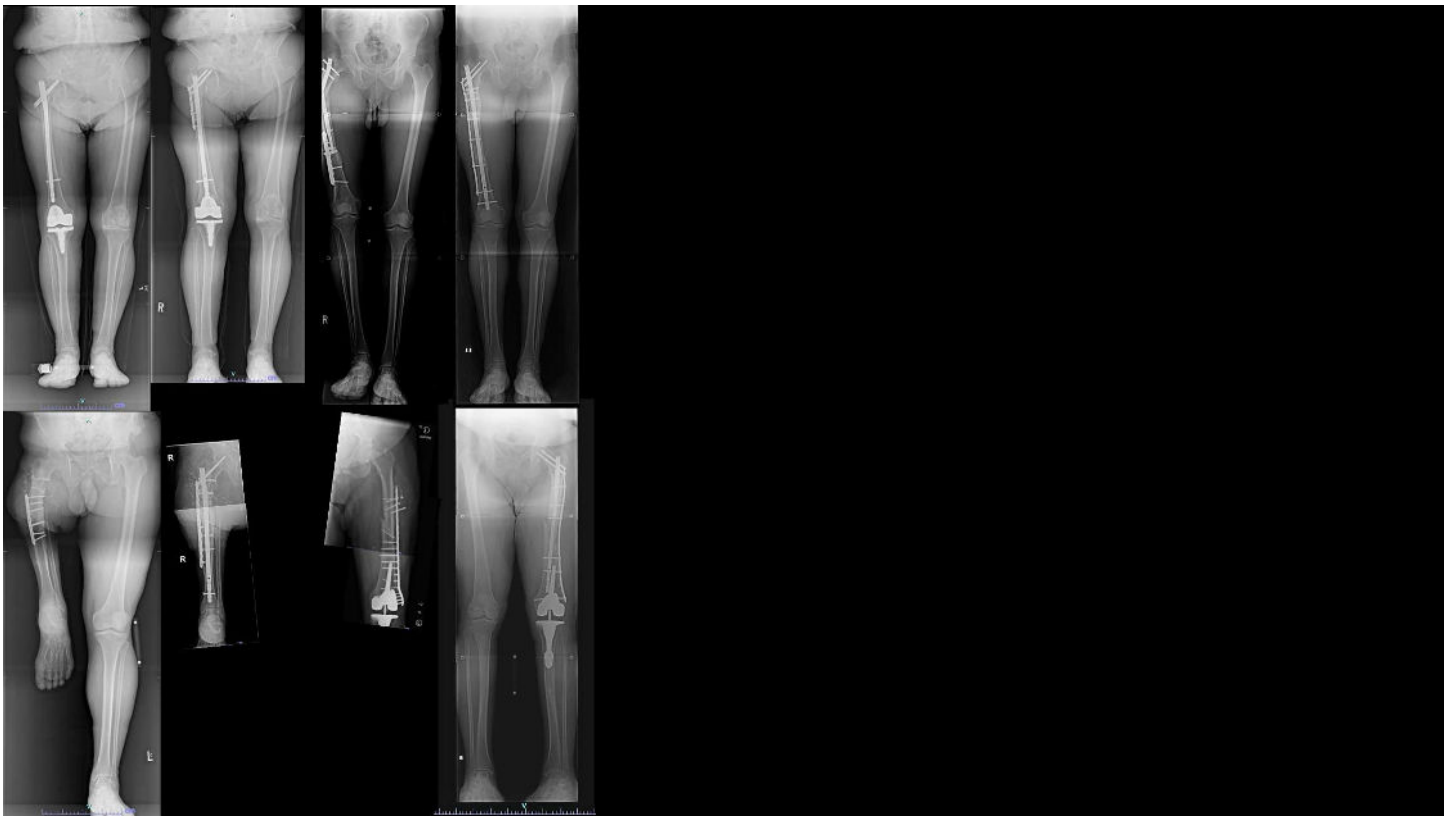
Question: Does linking a large fragment plate to the cephalic screw of femoral reconstruction nail as a tension band permit safe immediate weightbearing and promote union after failed femoral lengthening or fracture repair?

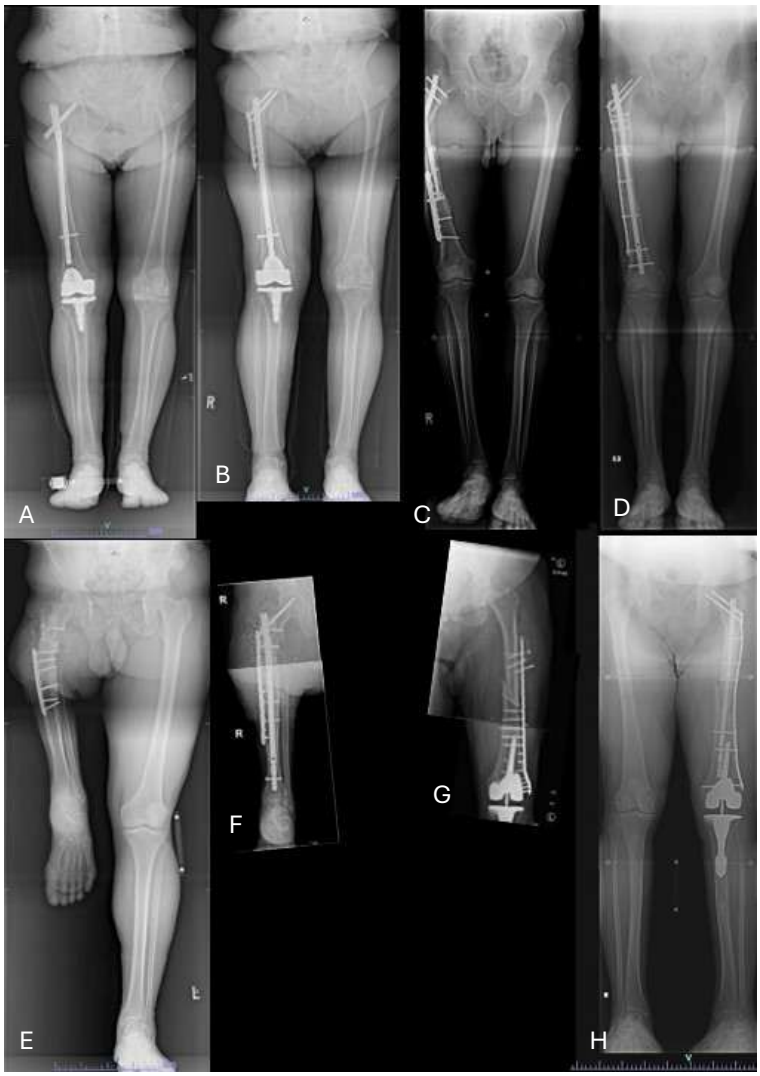
Answer: A case series of 7 patients was identified from one surgeon's case log. Following removal of previous implants via a lateral subvastus approach, the nonunion site was debrided, biopsied, and reduced. A reamed piriformis entry medullary femoral reconstruction nail was inserted and locked proximally using a 6.5 mm recon screw in the cephalic position. A 4.5 mm large fragment plate was contoured to the lateral proximal femur. The proximal hole was modified with a 4.5 mm drill bit to accommodate a second 6.5 mm recon screw, which was inserted through the plate and the nail into the femoral head and neck. The plate was then secured to the shaft with a Verbrugge clamp and tensioned using an articulated tensioning device and/or sequential eccentric insertion of cortex screws. The nail was secured distally with an interlocking screw. Autograft bone harvested from the gluteal pillar of the ilium was applied to the nonunion site. Postoperatively, full weightbearing and unrestricted motion were encouraged.

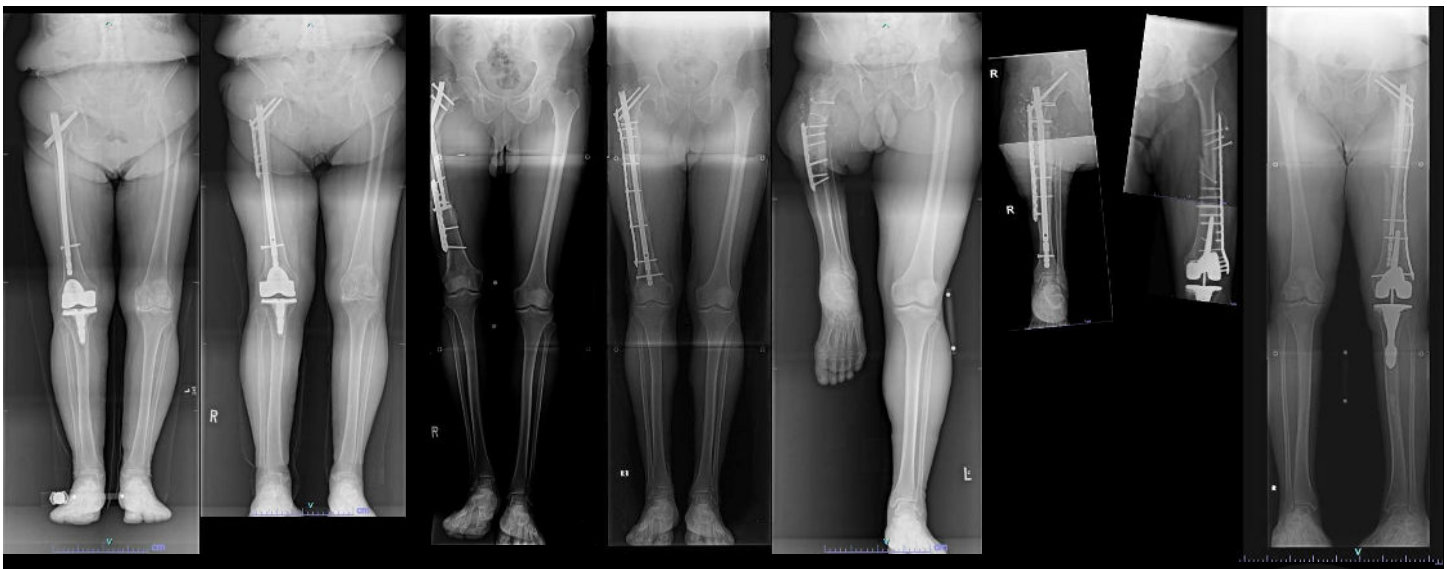
Results: Seven patients (6 male, 1 female) with a proximal femur diaphyseal nonunion after failed lengthening or fracture repair were treated with the plate−tensioned−nail construct and autologous bone graft (mean volume 29 cc, range 10−40 cc). The mean time to mobilization was 1.2 days postoperatively (range 1−2). All patients achieved clinical and radiographic union within 6 months. At 6 months, the mean PROMIS percent of normal improved +18.3% and the mean PROMIS Physical Function improved +3.2. No patient experienced a postoperative complication, including infection, implant failure or reoperation.

Conclusions: A "plate−tensioned−nail" construct augmented with autograft bone permits immediate unrestricted activity and reliably achieves union of femoral diaphyseal nonunion following failed lengthening or fracture repair.


A
B
C
D







- Series: 7 patients, mean age 46.6 years (range 19-81 years)
- Plate-tensioned-nail with autograft bone augmentation (mean 29 cc, range 10-4
- Mean time to mobilization 1.2 days
- 7/7 clinical and radiographic union within 6 months
- At 6 months, mean PROMIS percent of normal +18.3%, PROMIS Physical Functio

Three–Dimensional Virtual Modeling for Lower Limb Deformity Correction over Intramedullary Nail

*Roy Gigi, MD****
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Question: Herein, we propose a novel workflow for the correction and lengthening of complex lower limb deformities using a 3D modeling technique and patient–specific printed cutting guides, combined with the application of an intramedullary nail for fixation. This study aims to both introduce the proposed method and assess its clinical effectiveness.

Answer: Patient data included the patient's age and sex (at the time of surgery), deformity site and etiology, pre–operative measurements of the bone deformity (based on AP and LAT plain x–rays), surgery date, number of osteotomies performed, nail type, measurements of bone deformity after surgery (based on AP and LAT plain x–rays), time–to–bone union based upon follow–up plain x–ray images and complications.
Of 21 patients, 12 patients have completed at least 12 months follow–up at the time by the time of this paper's submission.

Results: Clinical and radiographic follow–up findings showed highly satisfactory alignment of the treated extremities in all cases. The average time for bone union was 12 weeks (range 4.5 to 30 weeks). This excludes one patient who was lost to follow–up and two patients still in follow–up.

Conclusions: This case series highlights how 3D–printed models with personalized cutting guides can enhance deformity correction with IMN in young patients with complex lower–limb deformities. 3D planning provides precise preoperative planning and preparation of closed medullary canals for the optimal IMN placement.

Higher ASA Score Associated with Complications and Mortality Following Nonunion Surgery

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Questions: The American Society of Anesthesiologists (ASA) physical status classification is commonly used to communicate a patient's comorbidity burden prior to surgery. The purpose of this study is to determine if higher ASA scores are associated with increased risk of complications following nonunion or malunion surgery.

Answer: We conducted a retrospective cohort study of all patients ‰¥18 years old with fracture nonunion or malunion of any bone who underwent surgical correction at a three–hospital health system between November 2015 and June 2024. Outcomes assessed included the incidence of postoperative complications within 90 days of surgery as well as the incidence of specific complications: mortality, vascular complications [including myocardial infarction (MI), venous thromboembolism (VTE), stroke, and transient ischemic attack (TIA)], postoperative infection, sepsis, hardware failure, pneumonia, renal complications (including acute kidney injury and urinary retention), postoperative anemia, nerve complications (including nerve palsy, paresthesia, and complex regional pain syndrome), and gastrointestinal (GI) complications (including Clostridium difficile infection and Ogilvie syndrome). Rehospitalization due to complications was also considered. Fisher's exact tests were used to assess statistical significance.

Results: Of 235 patients with reported preoperative ASA scores, 18.3% (n = 43) had an ASA=1, 53.6% (n = 126) had an ASA=2, 27.2% (n = 62) had an ASA=3, and 0.9% (n = 2) had an ASA=4. Higher ASA score was significantly associated with having one or more complications within 90 days of surgery ($p = 0.045$). Higher ASA score was specifically associated with greater incidence of sepsis ($p = 0.003$), vascular complications ($p = 0.018$), pneumonia ($p = 0.008$), and mortality ($p = 0.008$). Of note, mortality, sepsis, and pneumonia only occurred in patients with ASA scores of 3 or 4. ASA score was inversely associated with GI complications ($p = 0.017$). ASA score was not significantly associated with the other specific complications assessed or rehospitalization due to complication.

Conclusions: A higher ASA score is significantly associated with mortality and various life–threatening complications, including MI, VTE, stroke, TIA, pneumonia, and sepsis. These results suggest that preoperative patient health factors may be stronger determinants of postoperative complications or mortality than the surgical intervention itself. Orthopedic surgeons should weigh the benefits and risks of surgery to correct nonunions and malunions for patients with higher ASA scores, especially scores of 3 or 4.

Is it Time to Rethink Our Understanding of Contralateral Femoral Version?

Alyssa Barré, MD; William Ross Taylor, MD; Jonathan Stark, BS; Grace Brooks, BS; David Wilson Skinner, BS; Paul E Matuszewski, MD
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Question: Femoral version is critical in lower extremity mechanics and reconstruction of the femur. Abnormal anteversion, which exceeds this range, can lead to gait abnormalities and increased risk of joint pain and instability. The contralateral femur is often used as a template to assess femoral version while fixing fractures, reconstruction and deformity correction. We hypothesized that a large proportion of individuals have version differences and that patients with version measurements outside the normal range are associated with larger differences between each side. This has implications in reconstruction and fracture care.

Answer: Femoral version was measured in all patients who underwent CT of bilateral femurs over the last 5 years, and in patients who underwent CT angiography with lower extremity runoff over a 6–month period. Demographic information including sex, age, and race were recorded. Subjects who had a history of prior hip/knee arthroplasty or hardware anywhere in the femur, or above knee amputation were excluded. Additionally, patients with evidence of congenital and or acquired femoral deformity (eg, Ollier's, Perthes) were excluded. Variation in femoral version across all subjects and within/between demographic groups was calculated and analyzed.

Results: A total of 816 hips were assessed in 408 patients. The mean femoral version was 12 degrees (95% CI [11.4 – 12.6]). The mean difference between left and right was 6 degrees (95% CI [5.5–6.5]). 62.5% of hips had version measurements outside of the historical 'normal' (10–20). 43% of patients had greater than a 5–degree difference from each side, 16% had a greater than 10–degree difference between each side. Patients with version measurements outside the normal range (10–20 degrees) had a greater chance of having at least a 5–degree difference between each side than patients within the normal range (21% vs 14%, $p < 0.001$).

Conclusions: Almost 20% of patients have differences of greater than 10 degrees between measured femoral version. Patients with increased (or decreased) version of the femur have a higher likelihood of having differences between contralateral hips. This has implications in reconstruction and fracture care and suggests that utilizing the other limb as template may not be as accurate as we think.

Healing Wounds: Early Experience with Transverse Tibial Transport

Jessica C. Rivera, MD, PhD; Meredith Warner
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Question: Transverse tibia transport is a surgical technique that exploits the robust biological effects of distraction histogenesis to aid wound healing. The procedure involves a cortical window corticotomy which is then transported transversely with a small external fixator which achieved FDA approval in recent months. The process of distraction promotes the vascular regeneration and cellular metabolism known to occur as a result of other Ilizarov techniques. As a result, this approach is showing promise for healing conditions where the distal tissue is disadvantaged such as chronic wounds. This report aims to describe the early experience with this technique for treatment of challenging wounds.

Answer: A consecutive case series of transverse tibial transport procedures was compiled between two surgeons with experiences in limb salvage procedures. Included patients underwent transverse tibia transport with one system followed by one week latency, two weeks of transverse transport at 0.5mm twice daily, one week of cortical return at 1mm twice daily, and two additional weeks of healing prior to device removal. Wound progress was noted for this descriptive case series.

Results: Seven patients underwent the transverse tibial transport procedure with six completing care at the time of this report. All wounds were present for at five months or more and recalcitrant to other therapies. Wound etiologies included diabetic wounds in four patients, chronic venous stasis wound in one patient, chronic traumatic wound and underlying calcaneal osteomyelitis in one patient, and chronic traumatic wound with underlying tibial osteomyelitis in one patient. Multidisciplinary care was required in most cased for on going medical care, infectious disease treatment, and wound care. For patients with complete treatment, wounds successfully healed. No pin site problems were noted for the short frame time. One patient developed a hematoma at the transport site which resolved with a bolster dressing.

Conclusions: Transverse tibia transport, premised on the known biological advantages promoted by distraction histogenesis, is a promising technique. For our practice in a state consistently among the top three leading states in diabetes frequency and complications, such a novel tool may provide an option for patients at risk for limb loss due to chronic wounds. Prospective data collection is ongoing.

Session II:

Pediatrics I

Elizabeth Hubbard, MD, Moderator

Comparative Analysis of Limb Lengthening Complications in Children Aged 5 to 8 Versus Other Pediatric Age Groups

Akram Al Ramlawi, MD; Michael Assayag, MD; Philip K McClure, MD;
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Question: Children aged 5 to 8 years may have limited ability to adhere to postoperative care instructions following limb lengthening surgery. This study investigates whether children in this age range experience higher complication rates compared to children younger than 5 or older than 8.

Answer: We conducted a retrospective review of consecutive pediatric patients undergoing limb lengthening at a single center using external fixators. Patients were allocated to two groups based on age at surgery: Group 1 (8 years, n = 40) and Group 2 (5−8 years, n = 24). Data collected included length gained, incidence of pin site infections (both overall and those requiring surgery), surgical site infections (SSI), contractures (>15°), reversal of lengthening, hardware failures (e.g., pin breakage), and the total number of returns to the operating room. Differences between groups were analyzed using appropriate statistical tests; $p<0.05$ was considered significant.

Results: The mean amount of lengthening was comparable between Group 1 (7.2 cm) and Group 2 (7.5 cm). Pin site infections occurred in 20% of Group 1 versus 38% of Group 2 ($p = 0.0081$), with two patients in Group 2 requiring surgical intervention. SSIs occurred only in Group 2 (8.3%). Although contractures exceeding 15° were more frequent in Group 2 (21% vs. 12.2%), the difference was not statistically significant ($p = 0.227$), power analysis calculations showed that a total of 558 patients needs to be recruited, with a 1:1 ration, in order to reach statistical significance. Reversal of lengthening and pin breakage were also exclusive to Group 2 (1 patient each). Overall, patients in Group 2 had a higher rate of unplanned return to the operating room (5 vs. 3).

Conclusions: Children aged 5 to 8 years are at greater risk for complications, particularly pin site and surgical site infections, following limb lengthening procedures compared to younger or older pediatric cohorts. Targeted parent and patient education, along with intensified perioperative surveillance, may help mitigate these risks and improve postoperative outcomes.

Threaded Non−Telescopic Rods Demonstrate Less Rod Prominence and Migration than Non−Threaded Non−Telescopic Rods in Patients with Osteogenesis Imperfecta: A Case−Control Study

Jeanne M. Franzone, MD; Michael J. Cahill,*** Mahim Jain, Cristina McGreal,*** Richard W. Kruse
jeanne.franzone@nemours.org

Question: Osteogenesis imperfecta (OI) is a genetic condition characterized by inadequately or improperly produced Type I collagen. Affected long bone segments have a propensity to fracture and develop bowing deformities. The mainstay of pediatric orthopaedic intervention includes realignment and intramedullary rodding with telescopic intramedullary rods. Some OI patients, however, have canals too small for telescopic rods or have reached skeletal maturity. A recent development of a threaded non−telescopic rod (NTR) has introduced the question − does this threaded feature decrease complications and revision procedures?

Answer: This single−center retrospective study included patients with OI undergoing realignment and rodding of upper and lower extremity long bone segments with threaded−NTR (Slim Nail, Pega Medical) and non−threaded−NTR (K wires and flexible intramedullary nails). Patients were matched by age, bone segment and OI severity moving retrospectively, going back no further than needed with minimum of 1 year follow−up. The main indications for NTR included a canal too small for a telescopic rod, a patient nearing skeletal maturity or bone of too poor quality to accept telescopic rod fixation. Chart review identified patient demographics and surgical data.

Results: Thirty−five patients (19 females, 16 males) with OI who underwent realignment and intramedullary rodding of long bone segments with threaded−NTR rods were included with 35 age and severity matched control patients (18 females, 17 males) with non−threaded−NTR. Matched OI Types included: Type I−1, Type III−22, Type IV−10, Bruck syndrome−2. Bone segments included 13 femurs, 11 tibias, 9 humeri, 2 forearms (ulnas). The non−threaded−NTR group demonstrated 6 rod prominences requiring revision, 3 rod migrations, 1 patient with recurrent fractures, 1 periprosthetic fracture, 1 bent implant and 2 nonunions (tibia and femur). The threaded−NTR group included no prominences or migrations, 1 bent rod, 2 nonunions (tibia and humerus). There is a statistically significant benefit for use of the threaded−NTR ($p<0.005$), with a relative risk of complication in the nonthreaded−NTR group of 4.67 (95% CI 1.47−14.82) compared to the threaded−NTR group.

Conclusions: Use of a threaded non−telescopic rod in the setting of OI incurs less chance of a rod revision due to prominence or migration. In the setting of challenging OI bone and a patient population requiring frequent revision surgeries, it is important to evaluate the effectiveness of recently developed implants to help improve outcomes and reduce the already high surgical burden in this patient population. This work will also allow future cost analysis.

Relative Closure of Growth Plates in the Upper and Lower Extremity Using a Serial Radiographic Collection

Marlee R. Yancey, BA; Neelufar Raja, Ryan J. Furdock, Raymond W. Liu, MD
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Question: Knowing the relative closure pattern of different growth plates can aid clinical decision making in pediatric orthopaedics. For example, the ability to quickly evaluate remaining growth based on closure of physes in the hip and ankle can be helpful with guided growth decision making. Our study uses radiographs obtained from the Bolton–Brush Growth Study Center, which contains annual serial radiographs of all major joints for each subject, allowing us to determine relative order of closure within a single cohort.

Answer: Radiographs of the shoulder, elbow, wrist/hand, hip, knee, and ankle/foot were used to assess individual growth plates using a grade of 0 (open), 1 (incomplete fusion), or 2 (complete fusion). Age at complete fusion was recorded, and linear mixed model analyses were used to compare mean age of closure of upper and lower extremity growth plates by sex.

Results: A total of 3393 radiographs across 699 study visits from 43 females (mean age 12.2 y, range: 3.0 to 18.1 y) and 39 males (mean age 13.2 y, range: 4.0 to 20 y) were included. Average age of closure for the upper and lower extremities were calculated (Table 1). The minimum, 1st quartile, mean, 3rd quartile, and maximum age of complete closure were determined for the upper and lower extremities of males and females (Figures 1–4). Comparisons were made to key growth plates in each joint.

Conclusions: The order of closure varies slightly by sex, but follows a general progression. In the upper extremity, the olecranon and distal humerus are the first to close, followed by the 5th distal phalanx, the radial head and medial epicondyle, the remaining hand growth plates generally from distal to proximal, the proximal humerus, and, finally, the distal radius and ulna. The lower extremity has greater variability between the sexes, though the following is found in both females and males: the triradiate closes first, followed by the calcaneal apophysis. The distal tibia and proximal femur close prior to the distal femur and proximal tibia. The proximal fibula is last to close. These data may be useful in judging impending growth plate closure in children with radiographs of multiple joints.

Table 1. Average age, in years, of growth plate closure in the **A)** upper and **B)** lower extremities.

A

	Female	Male
Olecranon	13.3	15.7
Radial Head	14.5	16.5
Distal Humerus	13.4	15.5
Medial Epicondyle	14.5	16.2
Proximal Humerus	16.0	17.3
Distal Radius	16.2	18.5
Distal Ulna	16.3	17.4
1st Distal Phalanx	14.7	16.6
1st Proximal Phalanx	15.3	17.1
1st Metacarpal	15.1	16.6
5th Distal Phalanx	14.4	16.3
5th Middle Phalanx	14.6	16.5
5th Proximal Phalanx	14.7	16.4
5th Metacarpal	15.4	16.8

B

	Female	Male
Iliac Crest	14.8	16.1
Triradiate	12.8	14.9
Proximal Femur	13.7	15.5
Greater Trochanter	13.9	15.5
Distal Femur	14.6	16.3
Proximal Tibia	14.4	16.2
Proximal Fibula	15.5	16.8
Distal Tibia	13.9	15.4
Distal Fibula	14.7	16.2
Calcaneal Apophysis	13.7	15.3
1st Distal Phalanx	13.8	15.6
1st Proximal Phalanx	14.1	15.7
1st Metatarsal	14.6	16.1
5th Proximal Phalanx	14.2	15.9
5th Metatarsal	14.9	16.1

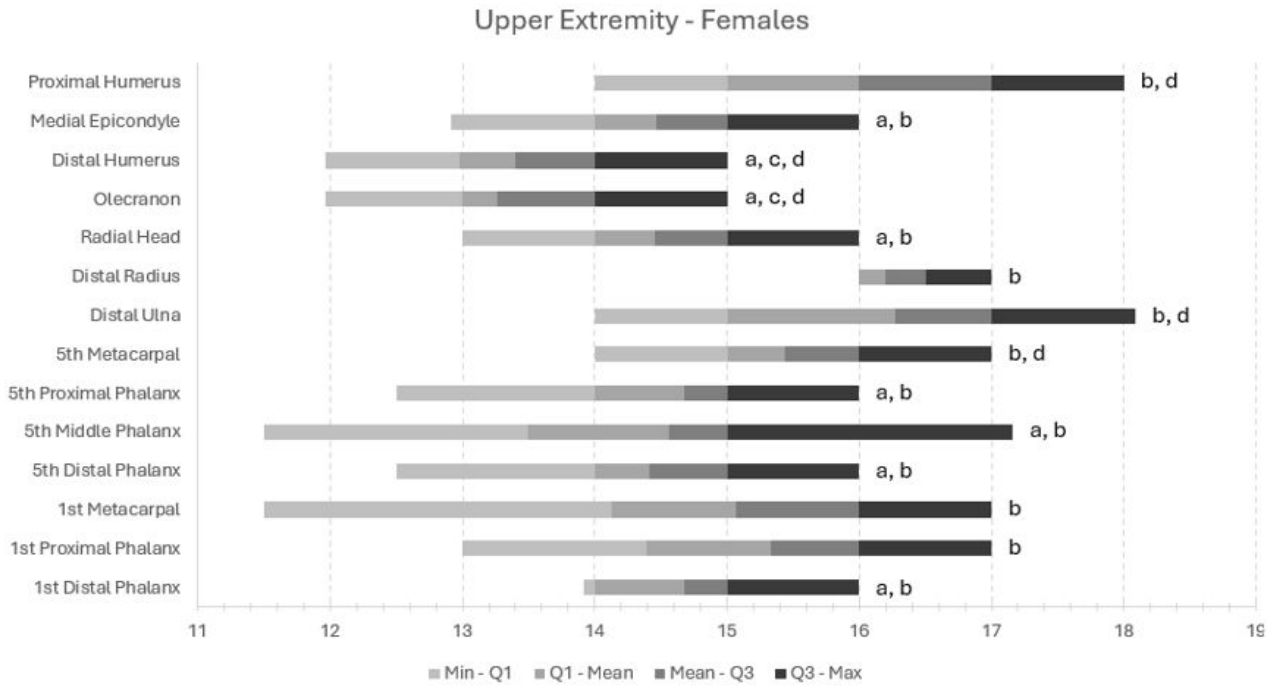

Figure 1. Timing, in years, of upper extremity growth plate closures in female adolescents (n = 43). Letters indicate statistically significant differences where a = compared to the proximal humerus, b = compared to the olecranon, c = compared to the distal radius, and d = compared to the 5th distal phalanx.

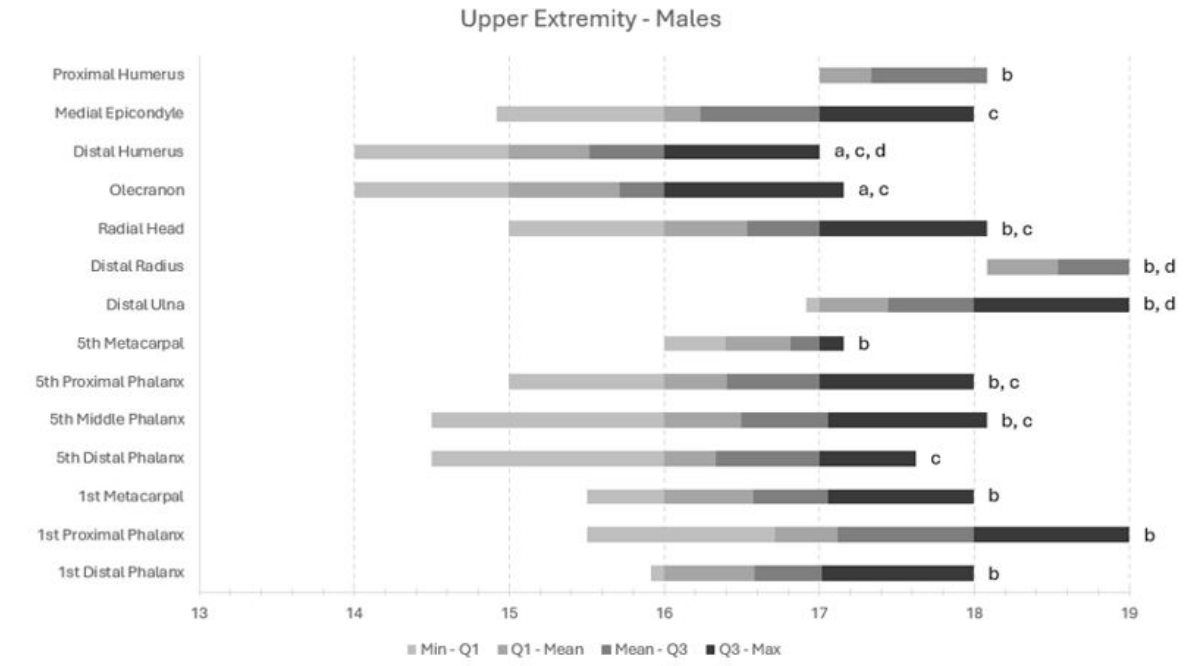

Figure 2. Timing, in years, of upper extremity growth plate closures in male adolescents (n = 38). Letters indicate statistically significant differences where a = compared to the proximal humerus, b = compared to the olecranon, c = compared to the distal radius, and d = compared to the 5th distal phalanx.

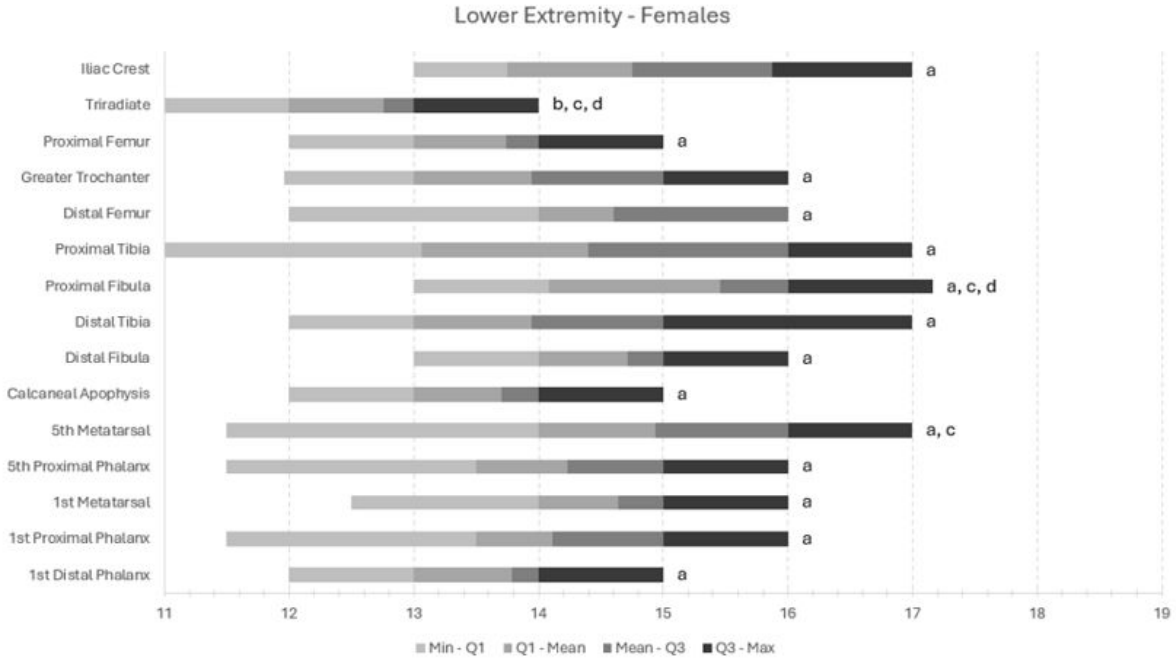

Figure 3. Timing, in years, of lower extremity growth plate closures in female adolescents (n = 43). Letters indicate statistically significant differences where a = compared to the triradiate, b = compared to the distal femur, c = compared to the distal tibia, and d = compared to the 5th proximal phalanx.

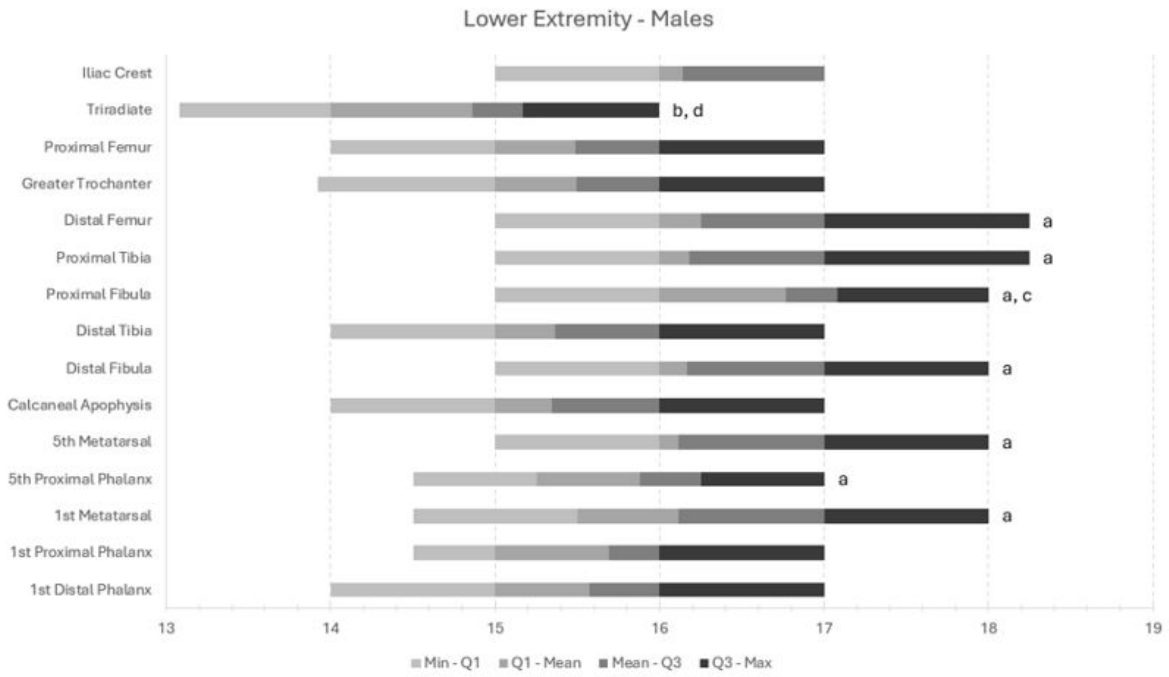

Figure 4. Timing, in years, of lower extremity growth plate closures in male adolescents (n = 39). Letters indicate statistically significant differences where a = compared to the triradiate, b = compared to the distal femur, c = compared to the distal tibia, and d = compared to the 5th proximal phalanx.

Acute Knee Flexion Contracture Correction in Patients with Arthrogryposis and Failed Distal Femoral Osteotomies

Sarah Nossov, MD; Natalie Williams
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Question: Patients with Arthrogryposis Multiplex Congenita (AMC) often present with knee flexion contractures in childhood. Distal femoral osteotomies have been reported to be successful in the cerebral palsy community in adolescents. Application of this surgery in young, school–age children, as especially seen in AMC, often recur and leave a residual deformity. Can acute correction of knee contractures with a posterior knee release and femoral shortening can improve mobility in pediatric patients with previously failed and prematurely executed distal femoral osteotomies?

Answer: This is a retrospective study of patients with AMC who underwent acute knee flexion contracture correction in the setting of failed distal femoral osteotomy from 2021 to 2023. 6 patients with AMC (2 female, 4 male) had 10 knee flexion contractures treated with an acute knee flexion contracture correction in the setting of a failed distal femoral osteotomy between 2021 and 2023 at an elective orthopedic pediatric hospital. Demographics, pre– and post–op clinical range of motion, measurements of radiographic extension deformity and flexion/extension contracture limitations were included as available. Ambulatory status and complications were noted.

Results: The average age of prior extension osteotomy was 5.8 years and 10.1 years at re–operation. Pre–operative sagittal deformity of the distal femur averaged 26.9 degrees and a radiographic extension contracture of the distal segment of 75.8 degrees sustained an average correction to 4.7 degrees radiographically. Clinically, contractures improved from an average of 40.5 to 14.1 degrees. Five complications were noted that included a physeal fracture, screw loosening, wound dehiscence, vascular injury, and heel pressure–sore. Improved gait was seen in all.

Conclusions: Distal femoral extension osteotomies should not be used in children with significant growth remaining for flexion contractures. Early results suggest that in AMC, children with failed distal femoral osteotomies and recurrent severe flexion contractures may be successful treated with an acute correction using posterior knee release and femoral shortening. All patients had improvement in clinical extension and comfort in bracing that permitted improvement in ambulation as early as 4 months post–operatively.

Distal Femur Extension Osteotomy for Neuromuscular Knee Flexion Contracture: A Novel Technique Using Intramedullary Fixation

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Question: Knee flexion contracture is a problem for adults impacted by neuromuscular disorders, as it contributes to difficulties with standing and mobility. Distal femur extension osteotomy is one treatment option; however, previously described techniques did not permit early weightbearing. Additionally, surgical treatment of adults has been overlooked and successful reconstruction can be complicated by osteopenia and challenges with healing. A new technique is presented that allows for immediate weight bearing while maintaining bony stability.

Answer: A consecutive case review was performed of 6 patients (9 knees) with spastic knee flexion contracture who underwent distal femoral extension osteotomy with intramedullary fixation. The technique consisted of fixator–assisted nailing using an intramedullary device. Neuromuscular etiology, patient demographics, and concomitant procedures, such as patellar realignment and hamstring lengthening were recorded. A radiographic review and sagittal measurement analysis was performed on preoperative, final intraoperative, and postoperative radiographs to compare maintenance of correction, as well as osseous and hardware stability (Fig. 1). Malunion was defined as loss of alignment greater than 5º.

Results: 4 patients had an underlying diagnosis of spastic cerebral palsy, 1 post–poliomyelitis syndrome, and 1 spastic hemiplegia secondary to traumatic brain injury. 5 cases (8 of 9 knees) were part of a SEMLS. All patients demonstrated radiographic and clinical union by 12 weeks. Blocking screws were utilized in all cases. There were no malunions, hardware complications, or revisions. No patients experienced major (including cardiac arrest, MI, stroke, DVT, PE, respiratory failure, sepsis, and infection) or minor adverse events (including blood transfusion, AKI, hematoma, pneumonia, transfusion, UTI, or wound dehiscence) perioperatively or within 90–days postoperatively. All patients were able to bear weight on postoperative day 1. One patient developed hamstring dystonia that responded positively to chemodenervation and a strength training regimen. One patient remained short of full knee extension postoperatively.

Conclusions: Distal femur extension osteotomy with intramedullary fixation using a fixed–angle device is a safe and effective technique in improving flexed knee gait and knee extension in patients with knee flexion contracture of neuromuscular etiology. This technique allows for immediate postoperative weightbearing without loss of alignment.

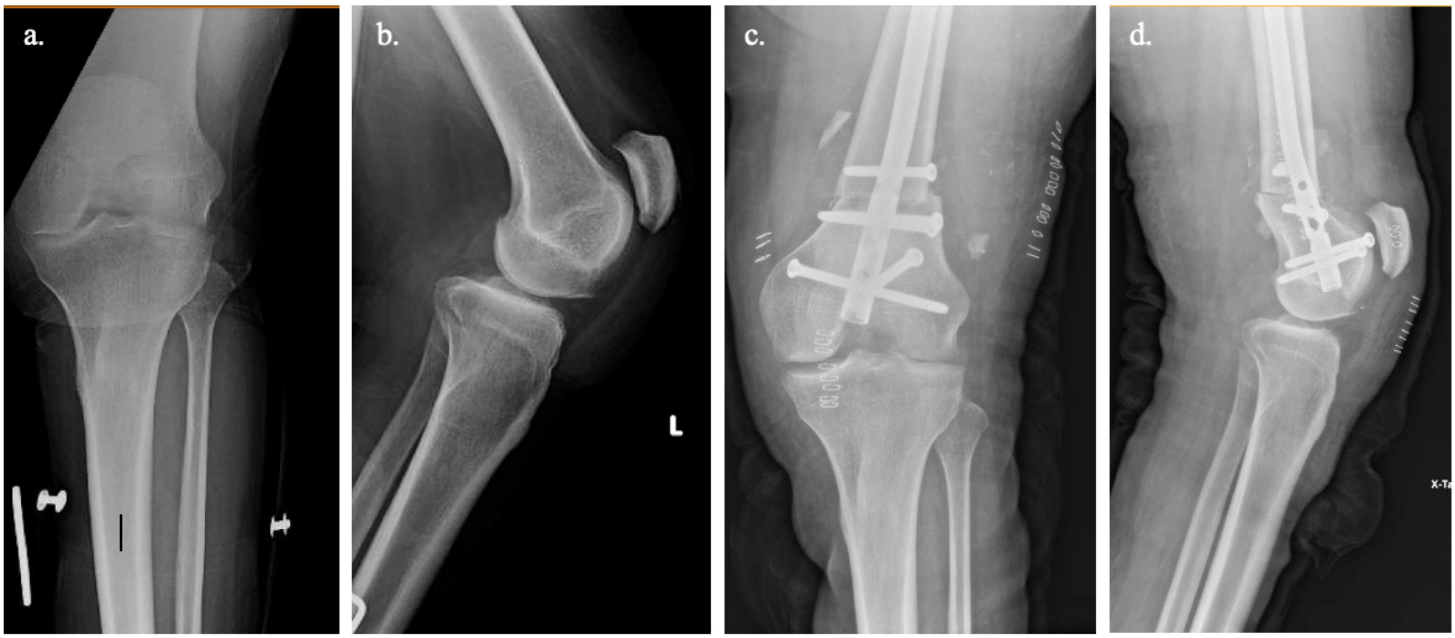

Fig 1. Preoperative (a, b) and postoperative (c, d) radiographs of a 47-year-old man with spastic hemiplegia. Sagittal correction was 37 degrees extension.

Session III:

Basic Science

Jessica C. Rivera, MD, PhD, Moderator

Comparison of Compressive Forces Generated Between Standard and Magnetic Compression Nails

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Question: Tibial shaft nonunions are challenging to treat due to the need to balance stability with micromotion. Compression nailing may improve outcomes by generating sustained compressive forces. Magnetic compression nails (MCNs), which offer adjustable and repeatable compression, may provide an advantage. The goal of this study was to compare compressive forces generated between standard intramedullary (IM) nails with compression screws to MCNs.

Answer: Twelve Sawbone tibia models transversely sectioned at midshaft were instrumented with a standard (n=6) or magnetic compression (MC) (n=6) nail. A Tekscan 5051 sensor with a central hole was placed at the section site to measure compression. Standard IM nails were compressed to 7.5 N·m; MCNs were compressed to match the same pressure. Specimens underwent two 7,200–cycle sets of angled loading (400–1,000 N at 30°) and two sets of internal rotation (IR) (0.5–10 N·m). MCNs were retightened by 0.5 mm if pressure dropped by >20%.

Results: Initial pressures were similar (Standard: 3.67 ± 0.85 MPa; MCN: 3.75 ± 0.61 MPa). Following the first and second 7,200–cycle compressions, the average pressures for the standard nails were 3.81 ± 0.69 MPa and 3.71 ± 0.67 MPa, while the MC nail readings were 3.63 ± 0.76 MPa and 3.64 ± 0.76 MPa, without retightening.

Internal rotation cycling caused pressure drops in both groups (Standard: 2.09 ± 0.94 MPa; MCN: 2.35 ± 0.73 MPa). MCN pressure was restored to 3.49 MPa ± 0.65 MPa with retightening. Standard nail pressure plateaued at ~2.07 MPa after the first IR cycle. The post–second set of IR cycling resulted in mean pressures of 2.07 ± 0.94 MPa and 2.34 ± 0.67 MPa in the standard and MC nail constructs, respectively. MCN constructs were retightened to 3.31 ± 0.86 MPa.

Conclusions: These findings show that both nail constructs maintained compression under typical axial loading conditions. Internal rotation caused pressure loss in both groups; however, only the MCNs allowed compression restoration through retightening. In contrast, pressure in the standard nails plateaued after the first internal rotation cycle and could not be recovered. These results suggest that MCNs can restore and maintain compressive forces under physiologic loading, supporting the necessary micromotion and consistent compression needed for fracture healing, particularly in cases of nonunion.

The Neuromuscular Knee Displays Unique Rotatory Tibiofemoral Pathoanatomy

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Question: Neuromuscular conditions characterized by spasticity and/or dystonia often result in deviations to lower extremity biomechanics, particularly affecting the knee joint. These structural changes can cause pain, instability, and diminished mobility, yet the surgical interventions designed to address these issues are primarily based on anatomical data derived from non−neuromuscular populations. This study aims to characterize the biomechanical differences between neuromuscular (NM) and non−neuromuscular knees using three−dimensional (3D) imaging techniques, ultimately informing more personalized surgical planning strategies and improving outcomes for this patient population.

Answer: A retrospective, case−control study was conducted using computed tomography (CT) scans of the knee from NM and non−NM patients. The NM cohort included patients diagnosed with cerebral palsy, multiple sclerosis, post−polio syndrome, demyelinating polyneuropathy, or oligodendroglioma, all who exhibited lower−extremity spasticity or dystonia. The control cohort, while not free of pathology, consisted of individuals with non−NM conditions such as tibial torsion, femoral anteversion, or osteosarcoma. While these conditions may potentially influence knee biomechanics, they do not originate from neuromuscular dysfunction and thus serve as an appropriate comparator group.

3D virtual reconstructions of knee structures were segmented and analyzed using Mimics software (Materialise LLC, Plymouth, MI) to establish common anatomical landmarks and derive key patellofemoral and tibiofemoral landmarks. Tibial tuberosity−trochlear groove distance (TT−TG) and external tibiofemoral rotation were calculated. Mann−Whitney U test was employed to assess intergroup differences, with significance set at $p < 0.025$ (0.05 / 2, adjusted via Bonferroni correction). Minimal sample size calculation was performed with an initial subset for a power level of 0.8.

Results: 13 NM knees (age: 38.5 ± 16.2 years; sex (f/m): 9/4) and 10 control knees (age: 28.5 ± 10.2 years; sex (f/m): 9/1) were included in the study. Significant differences between TT−TG distance and external tibiofemoral rotation were found. Neuromuscular knees exhibited an increased median TT−TG distance (20.72mm vs. 14.54mm, $p = 0.0118$) and greater tibiofemoral rotation (9.82° vs. 2.35°, $p = 0.0024$).

Conclusions: This study shows elevated tibiofemoral rotation and TT−TG distance in NM knees compared to non−NM knees. Previous literature has shown that external tibiofemoral rotation increases TT−TG, explaining most of the TT−TG difference found. This suggests an underlying rotational deviation prevalent in NM patients that may contribute to lateral patellofemoral instability and maltracking. Exacerbated by spasticity−related muscle overloading on the joint, these abnormalities could lead to progressive joint degeneration in the long−term. Standardized surgical procedures which primarily treat elevated TT−TG may not be optimal for mitigating these rotational abnormalities.

The Neuromuscular Knee Displays Unique Rotatory Tibiofemoral Pathoanatomy
continued

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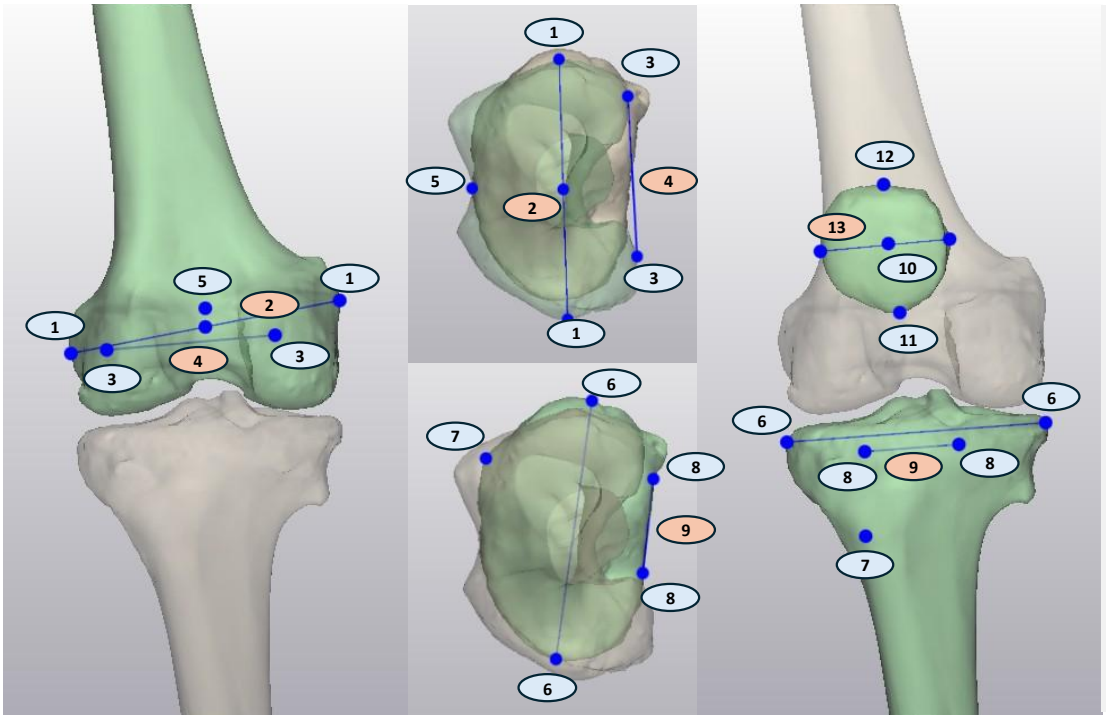
Integrating 3D imaging into preoperative assessments could improve patient−specific surgical planning and promote more precise interventions tailored to NM biomechanics. Future research should further investigate condition−specific variations in rotational abnormalities and should explore the clinical impact of rotational deformities on long−term functional outcomes and rehabilitation strategies for NM knees.

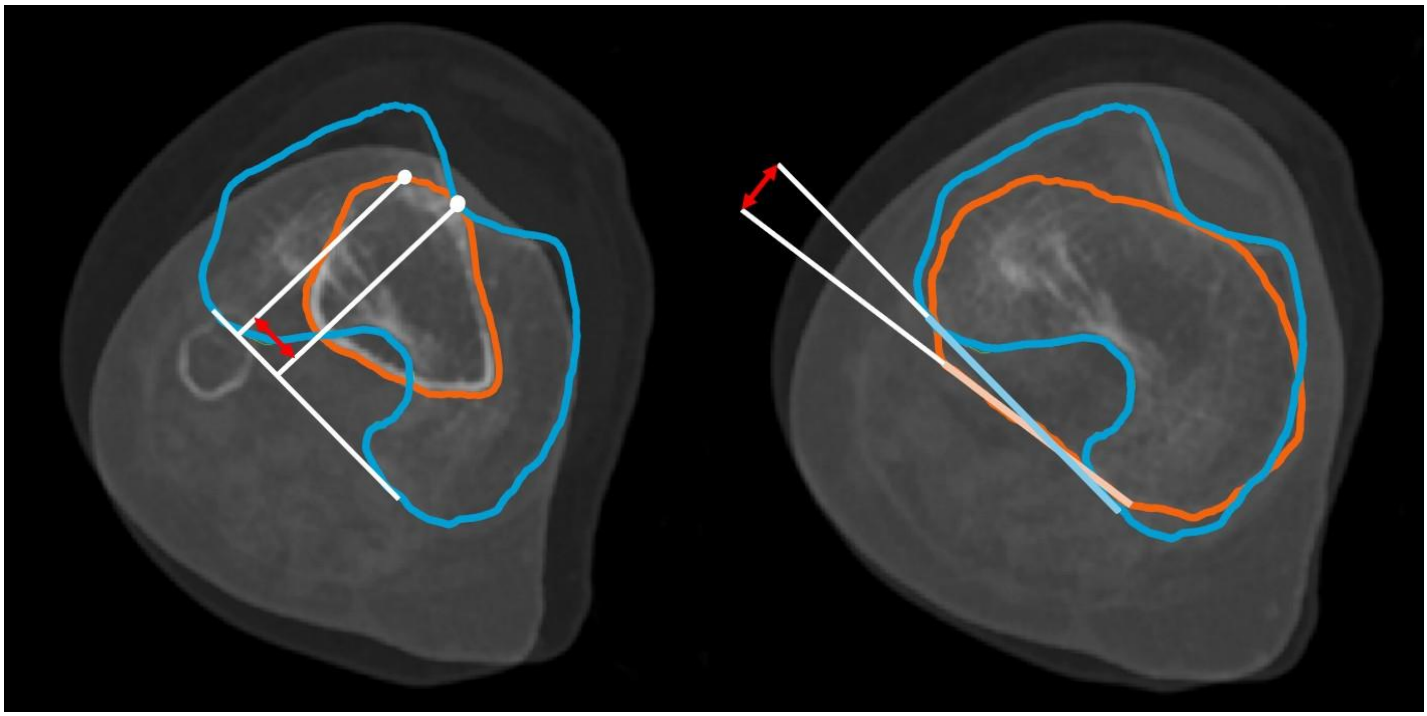
Conclusions: An acute osteotomy of the ulna improves radiographic deformity and reduces the radial head in patients with MHE. The most common complication is the development of a distal ulnar deformity which may be symptomatic and require surgical correction. A small percentage may re−subluxate; continued surveillance is recommended.



1. Femoral Epicondyles
2. TEA
3. Posterior Femoral Condyles
4. PCRL
5. TG
6. Tibial Plateau Points
7. TT
8. Posterior Tibial Plateau
9. TPL
10. Patellar Center
11. Patellar Tendon Insertion
12. Patellar Superior Apex
13. Mediolateral Patellar Line

TT-TG Distance

Tibiofemoral Rotation



Performance Comparison of Medical and Non−medical Wire Saw Designs for Surgical Bone Cutting

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Question: Gigli saws are specialized medical wire saws widely used in limb reconstruction surgeries due to their ability to create precise bone cuts through minimally invasive techniques. However, commercially available, medical−grade Gigli saws frequently experience jamming or breakage during use, presenting a need to identify optimal wire saw designs. This study aimed to compare six different wire saw designs − including two commercially available medical Gigli saws and four non−medical saws − focusing on cutting quality, heat generation, cutting efficiency, and durability under stress.

Answer: An MTS mechanical testing system (Frank Bacon, Model 1122) was utilized to uniformly advance foam blocks (Sawbones Solid Foam, 40 PCF density) against wire saws oscillating at a consistent speed. Each saw underwent four test cycles, maintaining a constant advancement rate of 20 mm/min for 60 seconds per cut. Interface temperatures were measured with an infrared thermometer. Post−cutting tests included tension−to−failure evaluations to assess durability. Recorded parameters included the force required for cutting, number of oscillations, cut width, resistance to failure, and temperature changes at the saw−foam interface.

Results: The six tested saws displayed variations in design and wire diameter, categorized into three groups: four twisted wire saws (including two medical Gigli saws), twisted wire with embedded diamond saw (commercial stone−cutting saw), and single−wire saw with embedded diamonds (commercial thin cutting saw). No saw jammed or broke during testing. In tension−to−failure assessments, one medical saw with a dual twisted−wire design (one wire significantly thicker) exhibited the highest resistance (1636 N), whereas another medical variant with a thinner wire intertwined between two thicker wires had markedly lower resistance (486 N). Non−medical saws showed intermediate tensile strengths. The maximum recorded temperature during cutting was 28.5 ºC, indicating minimal thermal risk for all saw designs. Cut widths varied substantially, with the thin, single−wire diamond saw producing the narrowest cut (0.5 mm) and the thicker diamond−embedded saw intended for stone cutting producing the widest (2.5 mm). The thin, single−wire diamond saw required the lowest force for cutting (64 N), followed closely by the two medical devices (66 N and 83 N).

Conclusions: This study demonstrates significant performance variability among medical and non−medical Gigli saw designs. The thin, single−wire diamond−embedded saw presented the most favorable performance combination, characterized by superior tensile durability (795 N), minimal cutting resistance, and exceptionally narrow cuts. These findings suggest potential advantages in utilizing non−medical wire saw designs or integrating specific features, such as diamond embedding, into medical−grade Gigli saws to enhance surgical outcomes.

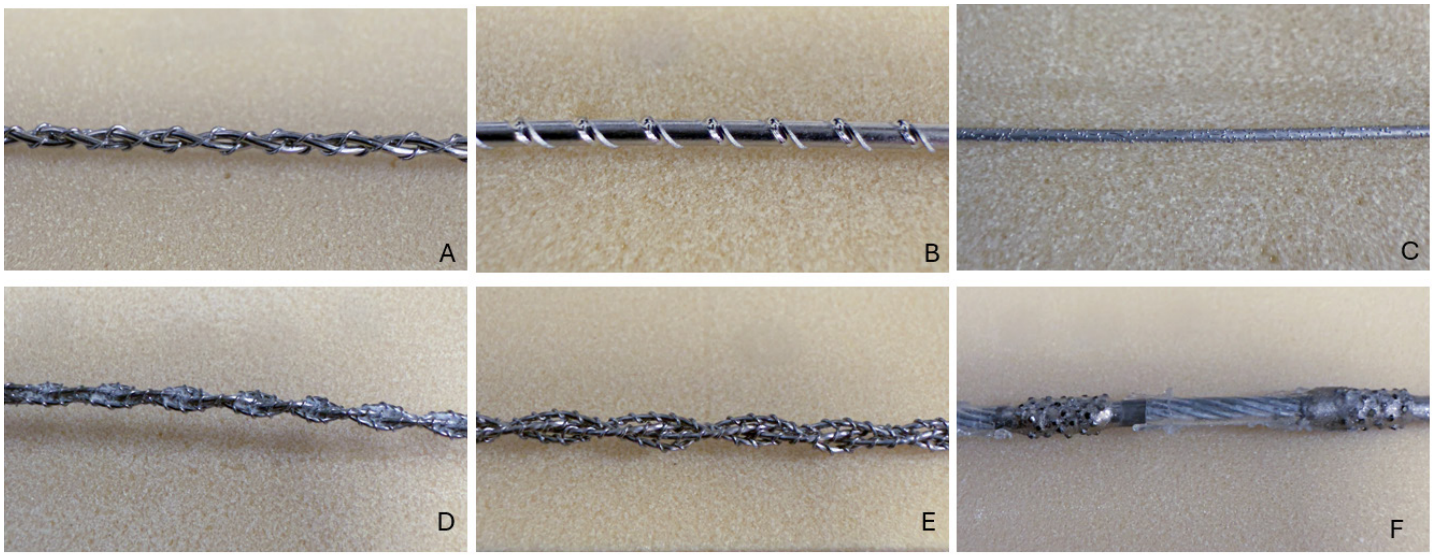

Figure 1. A) Commercially Available Gigli Saw Design #1; B) Commercially Available Gigli Saw Design # 2; C) Single-Wire Diamond Saw; D) Emergency Camping Chainsaw; E) Triple Spiral Wire Saw; F) Thick Diamond Cable Saw

Digital Monitoring of Patients Undergoing Orthopedic Deformity Correction: Feasibility and Patient Acceptability

Pernille Damborg Clasen, Research Nurse; Lili Worre Høpner Jensen, Tina Lyngholm Jensen, Arash Ghaffari, Trine Rolighed Thomsen, Harshit Mahapatra, Ole Rahbek***, Soren Kold
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Question: Integrating real–time monitoring technology and asynchronous communication pathways to track patient health after discharge for orthopedic deformity correction may enhance patient care and provide timely data for necessary interventions. However, many healthcare technologies face challenges when implemented in clinical practice. Therefore, interventions need to be tested for feasibility and acceptability. This study assesses the feasibility and patient acceptability of a monitoring system including an activity tracker, a pain and medication tracking app, and a communication tool.

Answer: The monitoring system comprises 1) Activity tracker (SENS Motion, SENS Innovation Aps), 2) App for registering pain and medication intake (OrtoApp, Alexandra Institute), and 3) a simple messenger–like communication tool for asynchronous communication between patient and their healthcare team (LetDialog, VISMA). Retention strategies include continuously monitoring participants, providing activity feedback, and sending reminders for data upload. Eligible participants are patients undergoing lower limb deformity correction at Aalborg University Hospital (October 2023€“December 2024). Patients are included four weeks prior to surgery, and monitoring continues for three months after surgery. Feasibility is assessed by recruitment success, compliance with sensor wearing time, adherence to upload of data in OrtoApp, and usage data of LetDialog. Acceptability is explored by semi–structured individual interviews with participants, based on a theoretical framework of acceptability.

Results: All ten patients (female n= 3, male n=7) have concluded the three–month postoperative monitoring and follow–up period (Figure 1– attached as PFD). Eight of ten patients used the sensor consistently across all days (100%) during both the preoperative and postoperative periods. One patient used the sensor 100% of the preoperative period and 92% of the postoperative period. One patient used the sensor for 98% of the preoperative period and 100% for the postoperative period (Figure 2 – attached as PDF). The median (range) proportion of days patients reported in the OrtoApp was for pain 52% (10% – 92%) and for medication intake 7% (0% – 78%). The median (range) of treatment–specific contacts from patients in LetDialog was 6 (2 – 21). Participants expressed perceptions of effectiveness, especially with the use of LetDialog. However, they also reflected upon burdens specifically related to technical challenges and a lack of notifications and feedback systems in SENS and OrtoApp. Overall, patients reported feeling safe and close to their healthcare team through the use of the monitoring system.

Conclusion: Digital monitoring of patients undergoing deformity correction seems both feasible and acceptable. Larger scale studies are needed to examine whether real–time patient monitoring also can improve patient outcome.

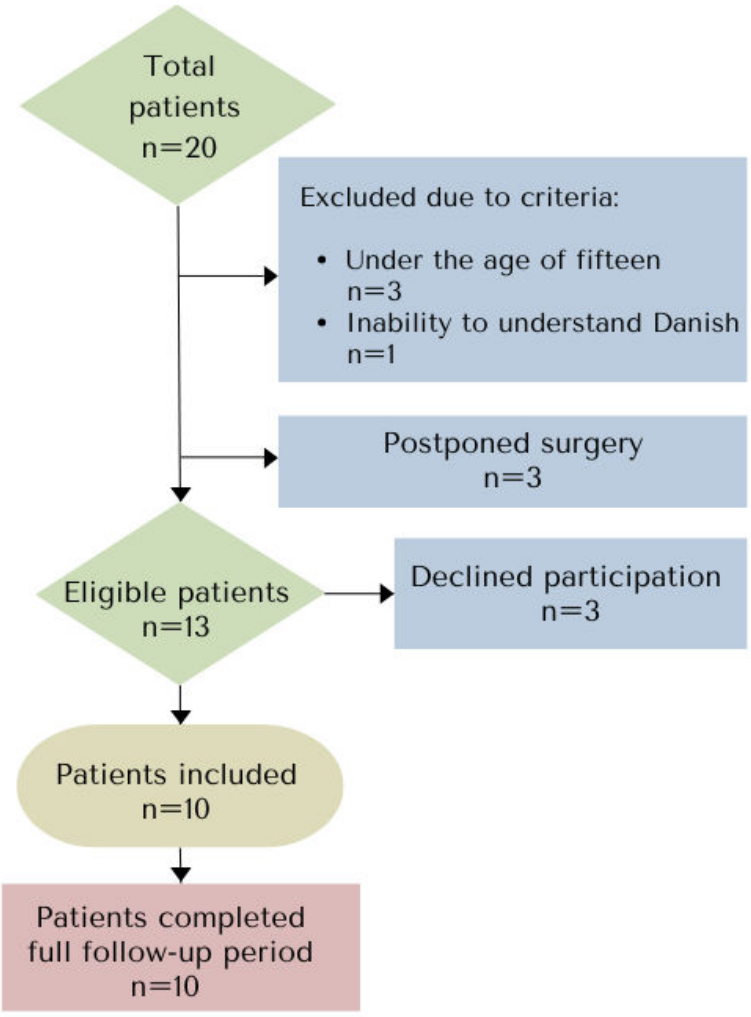

Figure 1 *- Flowchart illustrating the inclusion of participants through the study*

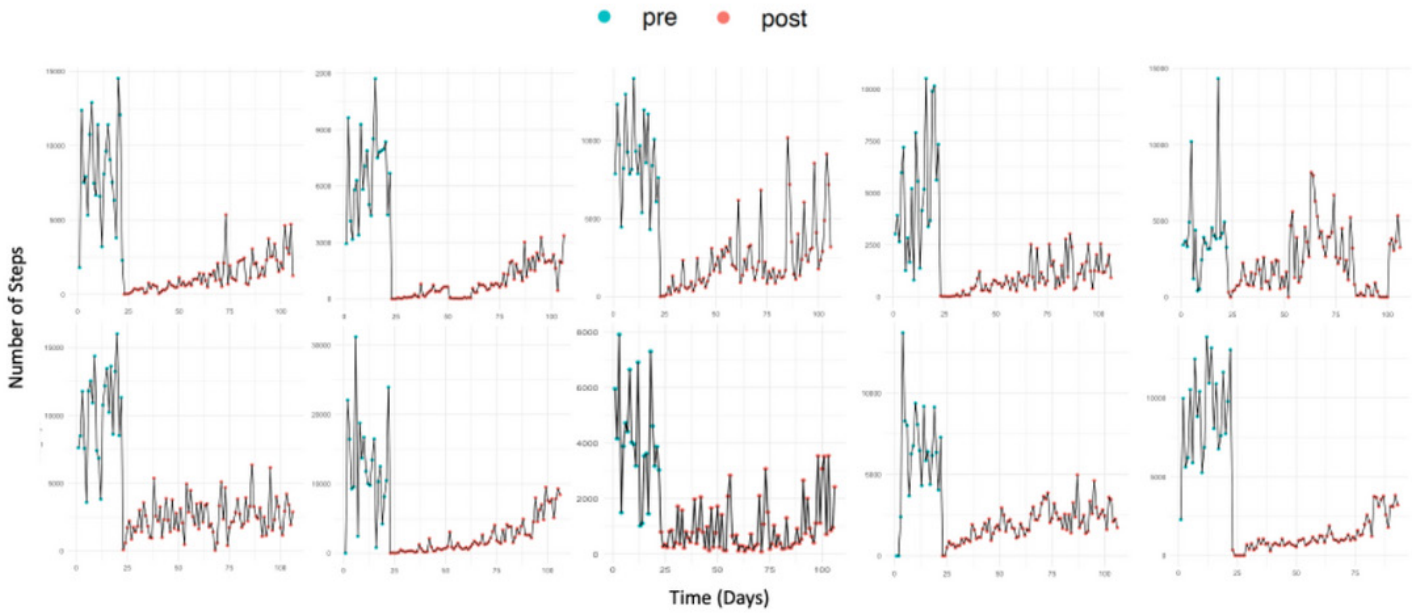

Figure 1 - *For each of the ten patients is shown the relationsship between patient activity in steps (pre- and post surgery) and sensor wearing time (days)*

The Effect of Closing Wedge Osteotomy on Leg Length Discrepancy: An Evaluation using Three–Dimensional Virtual Modeling

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Question: Femoral and tibial deformities can significantly impact lower limb alignment, often requiring surgical intervention through closing wedge osteotomy. Concerns about potential leg shortening following this procedure necessitate precise preoperative planning. Utilizing Three–dimensional (3D) virtual surgical planning and patient– specific cutting guides can enhance the accuracy of deformity correction. This study assessed leg length alterations resulting from closing wedge osteotomy and aimed to develop a mathematical model to understand the implications of angle correction on leg length.

Answer: In this retrospective study, 23 3D virtual long leg axis models from 22 patients were analyzed. Preoperative planning involved segmentation of patients' computerized tomographic images to create a 3D virtual model. Leg length measurements before and after closing wedge osteotomy were obtained from the virtual models and correlated with the angle of preoperative deformity correction.

Results: The median coronal angle correction following closing wedge osteotomy was 11.79° [9.68, 15.0]. The median shortening of the treated leg after the procedure was 1.18mm [–0.02, 2.68]. Spearman correlation analysis revealed no significant correlation between the degree of deformity correction and the change in leg length ($r_s = -0.26$, $p=0.23$).

Conclusions: This study provides valuable insights into the effects of closing wedge osteotomy on leg length discrepancy (LLD) in pediatric patients. Our results indicate that closing wedge osteotomy on either the distal femur or proximal tibia does not lead to a statistically significant alteration in LLD. Moreover, the degree of deformity correction does not meaningfully correlate with the extent of leg shortening. These findings emphasize the viability of closing wedge osteotomy as a reliable and crucial surgical option for addressing lower limb deformities in pediatric patients.

Session IV:

Trauma II

Stephen M. Quinnan, MD, Moderator

Strain Reduction Lag Screws as Adjunct Fixation in Recalcitrant Tibial Nonunions

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Question: Recalcitrant hypertrophic tibia nonunions remain a surgical challenge in orthopedic traumatology, often leading to prolonged morbidity, impaired function, and the need for multiple surgeries. Hexapod fixator techniques can be used to address infection, malalignment, and instability, and can also generate oblique vectors for sustained compression. This study describes a sequence of treatment in order to optimize the mechanical environment to facilitate union. Data on the use of adjunctive lag screws in tibial nonunion treatment is limited. This case series aims to describe the radiographic characteristics of the nonunion and report on the clinical outcomes of in a patient cohort.

Answer: This is a retrospective case series of data performed at two tertiary health care referral institutions between 2022 and 2025. The study included patients who developed tibial nonunions that were managed with hexapod fixation combined with percutaneous lag screw fixation. Demographics and computed tomography characteristics of the nonunion were reported. Fracture obliquity angle (FOA), is introduced as the angle between the best–fit line across the obliquity of the nonunion plane and a line perpendicular to the bone shaft. The primary outcome was union.

Results: This study involved 10 patients (9 males, 1 female) with a mean age of 51.4 years. All patients presented with tibia fractures, 9 of which resulted from high–energy trauma, and 5 were open fractures. The etiology of non–union was multifactorial, including infection, and instability. Prior to treatment with percutaneous lag screws, patients had undergone a mean of 3.6 interventions (range: 1–19), and the mean time from injury to percutaneous lag screw treatment was 4 years and 10 months (range: 1.1–18 years). Adjunctive procedures included hexapod fixators, osteotomy, and bone grafting. The outcomes showed that 9 patients achieved fracture union, while 1 patient failed to achieve union. The mean time to union after treatment with percutaneous lag screws was 9.5 months (range: 3–16 months). The fracture morphologies exhibited an oblique pattern, characterized by a mean obliquity angle (FOA) of 53.35°. Additionally, the mean fracture gap was measured at 4.9 mm.

Conclusions: Percutaneous lag screw fixation, when used as an adjunct to conventional treatment strategies may be an effective treatment strategy in vertical hypertrophic tibial nonunions. The results from this study suggest that this technique may offer an effective solution for tibial nonunions that demonstrate specific radiographic characteristics. Further studies with larger sample size are needed to further explore the effectiveness of this treatment strategy.

Characteristics and Anatomical Location of Infected Pin–Sites

Marie Fridberg, MD, PhD; Anirejuoritse Bafor, MD; Hans-Christen Husum, Christopher A. Iobst, MD; Ole Rahbek,*** Søren Kold
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Question: Assessment of more than 2000 pin–sites left the impression that certain anatomical locations and other characteristics of the pins were more likely to develop infection. This clinical experience is common despite it has not been reported in the literature. Larger data materials with each individual pin–site tracked might be the barrier, since previously published literature mostly report pin–site infections counted per patient.

The primary aim was to report the anatomical location and other characteristics for infected pin–sites for patients with external ring fixators on the lower extremity.

Question: Data was collected in a cross sectional designed study (1). The Modified Gordon classification System (MGS) bed site was used to grade signs of infection. Pus at the pin–site (MGS score 4) was considered a confirmatory sign of infection. Inclusion criteria was first event of a pin–site infection for this descriptive subgroup analysis. Findings are reported as counts and median values of the following characteristics: indication for treatment, symptoms of pain, frame construct, anatomical location and distance to neighbor pins or wires. Anatomical location and distance to neighboring pin–site was evaluated from digital images obtained at the examination day.

Results: 34 (2%) of 1970 pin–sites (83 patients) investigated were infected. 5 patients (8 infected pin–sites) were excluded after first infection event. 19 patients with 26 infected pin–sites (in total 205 pin–sites) were included. Of the 26 infected pin–sites, 17 were Ilizarov–transfixion wires and 9 were thicker bi–cortical inserted half–pins. Indication for treatment was acute fracture (7 patients), prior fracture with no infection (4 patients) and correction/lengthening procedures (8 patients). More than half of the infected pin–sites were in the correction/lengthening group (14 of 26 pin–sites). The majority (14 of 19 patients) had a general sensation of pain with the leg in resting position (median VAS score 3). The specific infected pin–site had a median VAS score of 4. The majority (21 out of 26) of the infected pins sites were located close to a neighbor pin–site (within 2–3 cm). The anatomical most troublesome segment was the proximal tibia metaphysis where 14 of the 26 infected pin–sites were inserted.

Conclusions: We found that the majority of infected pin–sites were located in the proximal tibial metaphysis. A Ilizarov–transfixion wire inserted at the proximal tibia segment laterally appears to be the most troublesome. The majority of patients having a pin–site infection defined as drainage of pus from the pin–site also experience pain from the pin–site.

Anatomical segment of pins and wires

Infected number (26) / total number (205)

19 PATIENTS

	Medial	Lateral	Anterior
TIBIA META PROXIMAL	P 1/1 W 2/18	P 1/1 W 7/20	P 3/26 W 0/2
TIBIA DIAPHYSIS	P 0/0 W 1/5	P 0/0 W 0/5	P 2/43 W 0/0
Posterior			
P 0/0 W 1/1 TIBIA META DISTAL	P 0/0 W 0/12	P 0/0 W 2/12	P 3/11 W 0/1
P 0/3 W 0/0 HIND FOOT	P 0/0 W 1/12	P 0/0 W 0/12	P 0/0 W 0/0
MID	0/0	0/0	0/0
FORE FOOT	P 0/0 W 2/10	P 0/0 W 0/10	0/0

References

1. Fridberg M, Rahbek O, Husum HC, Anirejuoritse B, Duch K, Iobst C, et al. Can pin-site inflammation be detected with thermographic imaging? A cross-sectional study from the USA and Denmark of patients treated with external fixators. Acta Orthop. 2024 Sep;95:562–9.

	Patients	Pins sites
First event of pin site with infection (MGS 4)	19	26
Indication for treatment		
Acute fracture	7	7
Prior fracture (no infection)	4	5
correction/lengthening	8	14
Symptoms of pain (VAS score)		
General pain in leg/foot with frame resting position (median)	14 (VAS 3)	
Specific pain score for infected pin (median)		14 (VAS 4)
Frame construction		
Wires		17
Pins		9
Close located pin or wire (within 2-3 cm)		15
Other infected pin sites (on same frame on same day)		21
No ohter infected pin sites (on same frame on same day)		5
Treatment		
Oral antibiotics last week	12	
Start oral antibiotics today	4	
Increased pin care last week	15	
Continue pin care as last week	18	
Wire removal	1	
Removal entire frame construct	1	
Anatomical location, segment		
Tibia proximal metaphysis		14
Tibia Diaphysis segment		3
Tibia distal metaphysis		6
Hindfoot		1
Midfoot		0
Forefoot		2

Differences Between Treatment Course Among Aseptic and Septic Nonunions and Malunions

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Question: If there are differences in treatment courses and outcomes among patients with septic and aseptic nonunions and malunions.

Answer: We conducted a retrospective cohort analysis with patients who received surgery for nonunions and malunions from November 2015 to June 2024 at a single center. Patients were included if they were over 18 when treated for a traumatic or iatrogenic nonunion or malunion with at least 90 days of follow–up after treatment. The injury was defined as infected by presence of sinus tract, exposed hardware, culture positivity or gross purulence noted intraoperatively. Outcomes recorded include whether union was achieved within a year or two years, time to union, length of hospital stay in those achieving union, and the presence of post–op complications within 90 days of definitive surgery (including severe medical complications, rehospitalization, unplanned reoperation, etc.). Associations between infectious status of nonunion/malunion and complications within 90 days and union within one year were analyzed using Chi–Squared or Fisher's exact test, and associations between infectious status and time to union and length of hospital stays were analyzed with Mann–Whitney U–test.

Results: 208 patients were included in the analysis, with 171 having at least 1 year of follow–up, 156 having at least 2 years of follow–up, and 143 achieving union. 63.7% of patients with aseptic injuries united in one year compared to 34.0% of patients with septic injuries ($p < 0.001$). After 2 years of follow–up, there is no significant difference between union rates in the aseptic and septic injuries. Septic injuries were also significantly associated with rehospitalization within 90 days of definitive surgery ($p = 0.004$). The median time to union from definitive surgery was 228 days and 402 days for aseptic and septic injuries, respectively ($p < 0.001$). The median length of hospital stays were 3 and 18 days for aseptic and septic injuries, respectively ($p < 0.001$). There was no significant difference in the presence of post–op complications or unplanned reoperation within 90 days.

Conclusions: Patients suffering from infected nonunions and malunions have different treatment courses than similar aseptic injuries and have increased potential for certain complications with treatment, despite similar overall union rates in 2 years.

A Review of Medullary Based Bone Transport

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Question: Critical bone defects are challenging pathologies to treat in orthopaedics. This study evaluates outcomes of medullary−based bone transport (MBBT), specifically plate−assisted bone segment transport (PABST) and transport nails.

Answer: We conducted a literature review (Pubmed, EMBASE, Google scholar, manual review of Journal of Limb Lengthening and Reconstruction) of MBBT for critical bone defects treated using PABST or transport nails [either Fitbone or PRECICE bone transport nail (BTN)].

Results: Twenty−three studies involving 91 patients [74 males, 16 females and 1 unspecified gender; 39 tibia, 51 femur, one with resection of knee joint and arthrodesis of femur and tibia) were included (Table 1). The average age was 41.3 years and average defect size was 69 mm. The latency periods in the studies included ranged from 5 to 17 days. Lengthening rate ranged from 0.5 to 1.75 mm/day, with 1 mm/day being the most common.

Bone Healing Index (BHI)
Reported BHIs ranged from 24.3 to 60 days/cm with an average of 44.6 days/cm (47.0 for Fitbone and BTN, 42.7 for PABST). However, the definition of BHI varied widely amongst studies.

Complications
Complications occurred in 51 out of the 91 patients. The Fitbone group experienced a higher complication rate (26 in 17 patients), most notably screw back out and infections. The BTN group had fewer complications (23 in 33 patients), most commonly delayed union, malfunction of the external remote control and wound healing issues. The PABST group also had fewer complications (28 in 39 patients), mostly involving secondary malalignment and stiffness/heterotopic ossification.

Conclusions: This study demonstrates promising outcomes of MBBT, with a slightly faster BHI and lower complication rate compared to traditional circular frame methods. Standardization of outcomes reporting, including consistent definitions for BHI and time to union, is crucial for enabling meaningful comparisons across studies.

Table 1. Outcomes of Studies for All Internal Bone Transport

Author	Year	Method	N	Bone	BHI (days/cm)	Time to Union (weeks)
Baumgart*[6]	1997	FIT	1	Femur and Tibia**	45	72
Kold[7]	2014	FIT	1	Tibia	45	20
Mikuzis[8]	2021	FIT	15	8 Femur, 4 Tibia	NM	NM
Ferner[9]	2020	BTN	1	Femur	30.25***	30
Zeckey[10]	2020	BTN	1	Tibia	30	26
Kern[11]	2021	BTN	9	Femur	46	NM
Stoneback[12]	2021	BTN	2	Tibia	53.25	32
Zuckerman[13]*	2021	BTN	2	Femur	21.41	52
Carrion-Martinez[14]	2022	BTN	1	Tibia	60	64
Blair[15]	2023	BTN	4	Tibia	41.4	43.53
Geiger[16]	2023	BTN	4	Tibia	63	58***
Hackl[17]	2023	BTN	9	4 femur, 5 Tibia	7.4	67
Krettek[18]	2017	CKTST	1	Tibia	NM	NM
Krettek[19]	2018	CKTST	2	1 Femur, 1 Tibia (same as above)	NM	NM
Barinaga[20]	2018	PABST	1	Tibia	56.9	72
Olesen[21]	2018	PABST	3	2 Femur, 1 Tibia	NM	NM
Olesen[22]	2019	PABST	9	5 Femur, 4 Tibia	Femur 24.3; Tibia 37.8	Femur 34; Tibia 30
Wright[23]	2019	PABST	3	3 Femur	NM	NM
Eldesouqi[24]*	2021	PABST	1	Tibia	78	26
Hwang[25]	2021	PABST	1	Tibia	NM	NM
Olesen[26]	2023	PABST	1	Femur	20	48
Summers[27]	2021	PABST	5	5 Femur	24	72.4
Freischmidt[28]	2024	PABST	15	7 femur, 8 Tibia	57	46

*Oncology

**Patient with Ewing's sarcoma s/p wide excision who underwent arthrodesis of femur and tibia with intramedullary nail; data reported in table is specific to this patient rather than the reported averages of the 12 patients included in that paper. Other eleven patients were eliminated as they were lengthening cases and not bone defect cases.

***Extrapolated from other data that was reported

NM = not mentioned

FIT = Fitbone

BTN = Precice Bone Transport Nail

PABST = Plate assisted bone segment transport

Femur Deformity Correction using an Intramedullary Nail

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Question: The femur, as a major weight–bearing long bone, can exhibit a diverse array of deformities. These deformities may be discrete and angular or broadly bowed and multiapical. They can occur in a single plane or span multiple planes (coronal, sagittal or axial). Such complexity makes surgical correction particularly challenging. However, intramedullary nailing (IMN), when combined with meticulous pre–operative planning and techniques such as the fixator–assisted blocking screw method (FABS), serves as an effective approach. The purpose of this study was to critically assess the safety, precision, and efficacy of IMN as a method for achieving accurate femoral deformity correction.

Answer: We conducted a retrospective review of patients who underwent acute femoral deformity correction using an intramedullary nail (IMN) between April 2016 and April 2024, with a minimum of one year of follow–up. Patients treated with lengthening nails were excluded from this study. Preoperative deformity correction goals were established for each patient, and postoperative accuracy in achieving these goals was assessed. Radiographic outcomes measured included mechanical axis deviation (MAD), mechanical lateral distal femur angle (mLDFA), and overall deformity magnitude. In cases involving simultaneous tibial correction, MAD was excluded as an accuracy metric to avoid confounding results.

Results: We evaluated 194 femurs from 135 patients who underwent femoral deformity correction with IMN. Of these, 154 femurs had purely rotational corrections and were excluded to focus on coronal or combined coronal and rotational deformities, leaving 29 femurs for analysis. The average patient age was 40.9 years, with 65.5% female patients. Deformities were predominantly congenital (17 femurs, 58.6%), with post–traumatic deformities accounting for 8 femurs (27.6%). Fourteen femurs demonstrated isolated angular deformities in the coronal and/or sagittal planes, while 15 exhibited combined angular and rotational abnormalities.

On average, corrections achieved were 30.4 mm ± 21.3 mm in MAD, 6.9° ± 4.3° in mLDFA, 13.8° ± 7.0° in focal deformity, and 20.6° ± 16.4° in femoral rotation. Preoperative goals were met with accuracies of 98.1% ± 2.1% for mLDFA, 95.5% ± 9.0% for MAD, and 84.4% ± 12.6% for focal deformity. Three patients (10.3%) experienced complications requiring additional intervention: one patient underwent exchange nailing due to delayed union, subsequently achieving healing, and two patients (6.9%) required secondary osteotomies for residual deformities. No infections requiring oral antibiotics or surgical intervention were reported.

Conclusions: Acute femoral deformity correction using intramedullary nailing is a safe and precise technique for managing complex multiplanar deformities. The approach demonstrated high accuracy in achieving planned corrections, with a low rate of complications that were effectively managed.

Session V:

Pediatrics II

L. Reid Nichols, MD, Moderator

Congenital Pseudarthrosis of the Tibia: Is Pharmacological Adjuvant Therapy Imperative for Bone Healing in X–Union?

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Question: Is Pharmacological Adjuvant Therapy Imperative to Obtain a X–Union in Congenital Pseudarthrosis of the Tibia?

Answer: A total of 21 patients with congenital pseudarthrosis of the tibia were operated on between 2017 and 2024 by the same surgeon. Among them, 10 were male and 11 female, all unilateral cases, with 11 affecting the right side and 10 the left. The average age at surgery was 5 years (ranging from 2 years to 11 years and 11 months).
Three patients were excluded because the objective was not to achieve X–Union.

Results: Paley's classification was used:
6 patients were classified as type 1,
2 patients as type 2 (one subtype a and the other subtype b),
1 patient as type 3,
9 patients as type 4 (2 subtype a, 4 subtype b, and 3 subtype c). Surgical techinique was used as described by Choy (2011) and Paley (2019) with small variations. Periosteum and iliac bone graft were used in all. No allograft added. Of the 18 selected patients, 6 had undergone prior failed surgeries (ranging from one to three procedures). Among these, 3 patients received doses of zoledronic acid (ZA). In 14 patients achieve a X–Union and 3 do not. All 3 patients that used ZA were in this group. No patients had Bone Morphogenetic Protein (BMP) added during surgery. The standard consolidation period was observed after 4 months, though in two patients, healing extended beyond 6 months (one taking 6 months and the other 8 months). After healing, all patients were prescribed a non–articulated below–the–knee orthosis with an anterior splint. Three patients required reoperation to replace the tibial diaphysis plates approximately 3 months after the initial surgery due to failure to adhere to orthosis use or premature weight–bearing. The average follow–up time was 3 years and 5 months (ranging from 8 months to 7 years and 6 months). During this follow–up period, no patients experienced refracture.

Conclusions: Despite the small number of cases, there is a clear tendency toward bone consolidation and a significant reduction in new fractures, even without the use of additional pharmacological treatments (ZA and/or BMP), if alignment is achieved and the limb is protected through orthotic use.

Diffusion Tensor Imaging of the Distal Tibia and Fibula as a Marker of Skeletal Growth in Pediatric Patients: A Preliminary Experience

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Question: Can diffusion tensor imaging (DTI) metrics serve as a biomarker of physeal activity to reflect growth trends of the distal tibia and fibula in a healthy pediatric population?

Answer: DTI is a non-invasive imaging technique that measures Brownian water motion to reveal tissue microstructure. DTI-based fiber tracking can recapitulate the columnar architecture of physeal growth, as the cellular membranes of the cartilage columns of the physis, adjacent metaphysis, and newly formed bone restrict the diffusion of water molecules primarily along a longitudinal axis. This allows DTI to indirectly measure physeal activity which can be quantified as tractography, with longer tracts indicating regions of accelerated growth (Figure 1). Our study is a retrospective analysis of healthy pediatric patients aged 7-16 years who underwent ankle magnetic resonance imaging (MRI) with sagittal DTI. Patients with poor imaging quality or physeal pathology were excluded from the study. We collected data on various tractography metrics, including fractional anisotropy (FA), tract count, volume, and length as well as traditional markers of pediatric growth including chronological and bone age, height, weight, body mass index (BMI), and z-scores derived from standardized CDC growth charts. Tractography metrics were recorded for each age group in male and female patients to document normative values. Spearman correlation (ρ) was used to evaluate relationships between ankle metrics and pediatric growth markers. Significant correlations were defined as those with a p value < 0.05. Moderate strength correlation was defined as $0.3 \leq \rho \leq 0.7$ and a strong correlation was defined as $\rho > 0.7$.

Results: The analysis included 68 total pediatric patients, 36 female patients (mean age: 12.5 ± 2.2 years) and 32 male patients (mean age: 12.8 ± 2.7 years). In the tibia, Spearman correlation analysis revealed moderate strength significant correlations between height z-scores and distal tibial tract count ($\rho = 0.385$), tibial tract length ($\rho = 0.309$), and tibial tract volume ($\rho = 0.382$). Similarly, Spearman analysis of the distal fibula also demonstrated moderate strength significant correlations between height z-scores and fibular tract count ($\rho = 0.414$), fibular tract length ($\rho = 0.387$), and fibular tract volume ($\rho = 0.422$) (Figures 2 and 3).

Conclusions: DTI tractography metrics derived from the distal tibia and fibula of healthy pediatric patients show significant moderate strength correlations with height z–scores, with greater tract counts, length, and volume seen in pediatric patients with higher population–standardized height z–scores. These findings suggest that DTI tractography can be a useful tool for assessing growth trends in pediatric patients with potential future clinical utility for evaluating physeal growth abnormalities.

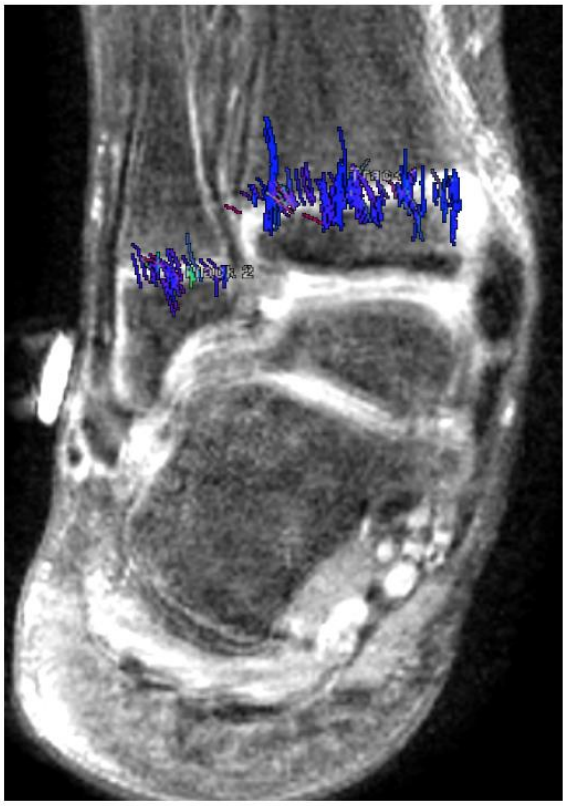
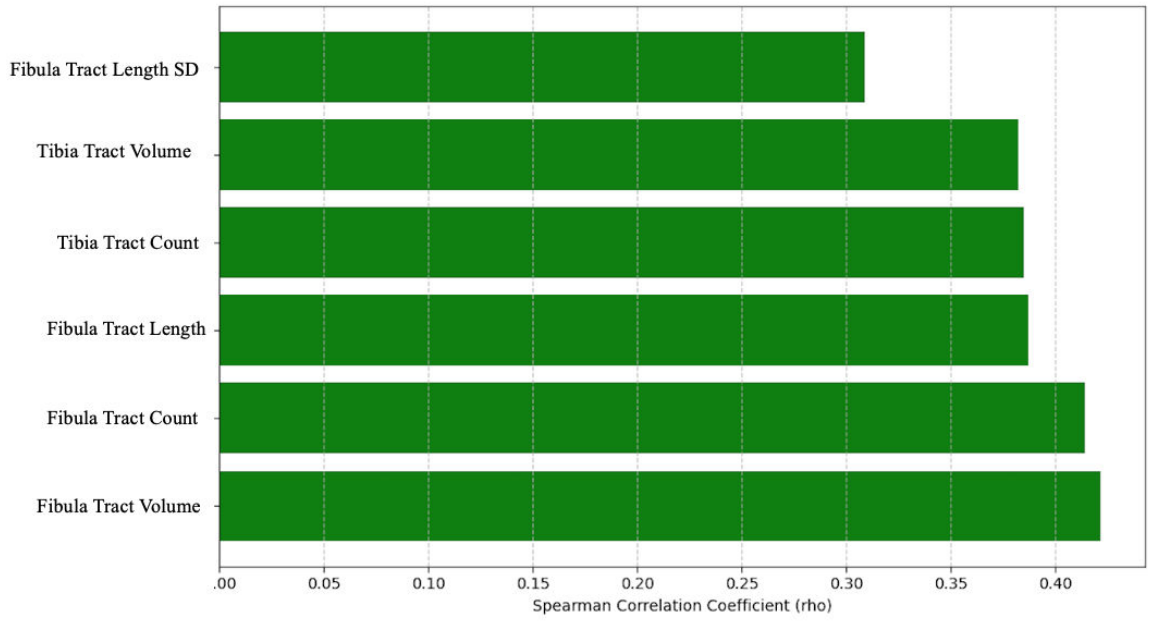


Figure 1. DTI Tractography of the Distal Tibia and Fibular Physis of a Pediatric Patient

Figure 2. Significant Correlations between DTI Metrics and Height Z-Scores



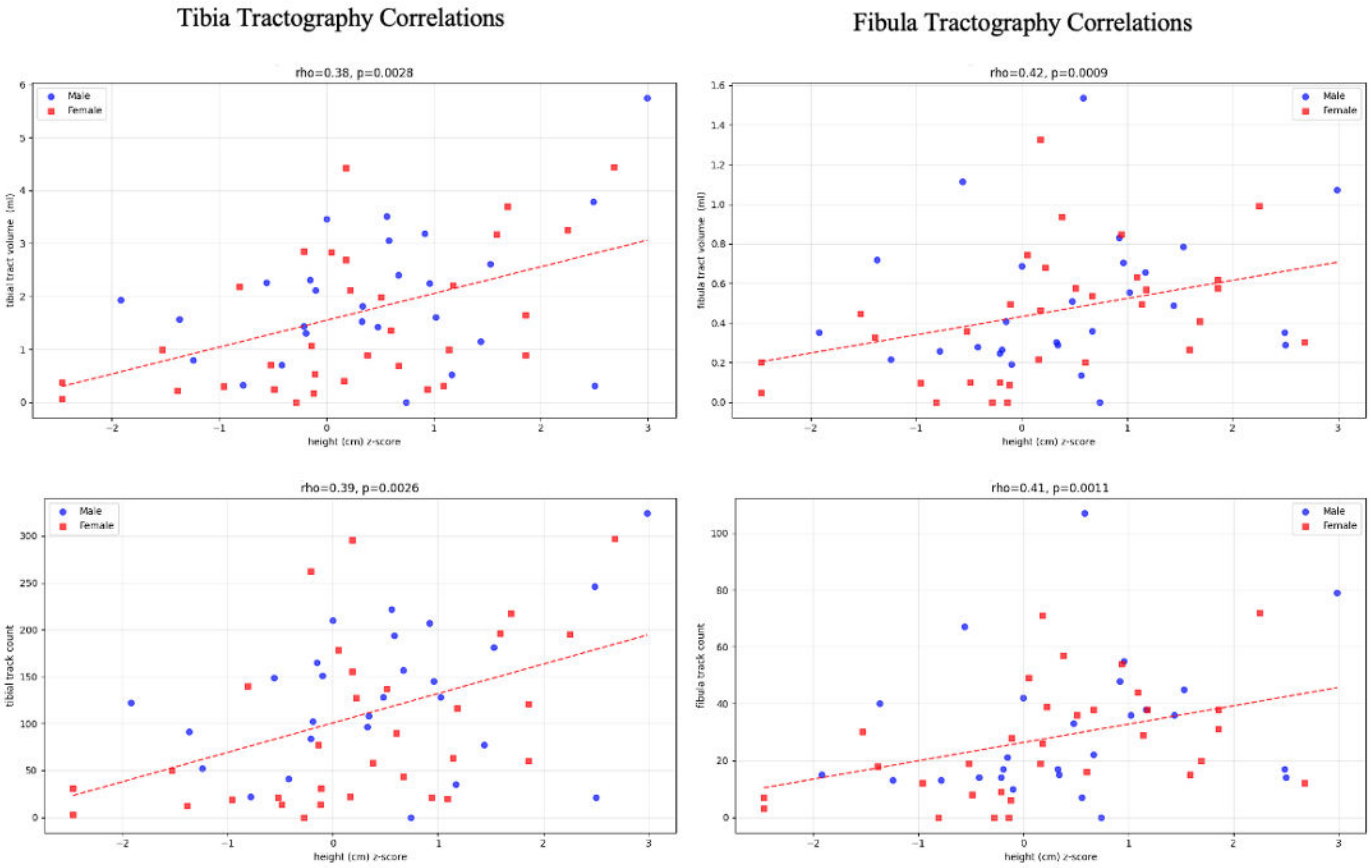


Figure 3. DTI Tractography Metrics and Height Z-Score Correlation Plots

So Many Surgeries: Can we Minimize the Number of Surgeries Performed for Deformity Correction in Severe Early–Onset Blount Disease?

Melinda Sharkey, MD; Zachariah Samuel, Ofir Horovitz, Eduardo Valero-Moreno, Leila Mehraban Alvandi, Edina Gjonbalaj
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Question: A subset of patients with early–onset Blount disease undergo multiple surgeries over their childhood to fully correct their lower extremity deformity. This study aims to evaluate preoperative characteristics that differentiate patients with early–onset Blount Disease who require multiple corrective surgeries from those needing only one. The early identification of patients with the more severe form of this disease will allow the development of surgical protocols to minimize the number of surgeries required for definitive deformity correction.

Answer: An IRB–approved, retrospective analysis was performed on patients with early–onset Blount Disease undergoing surgery between 2015 and 2024 at an academic, tertiary care center. Patients were categorized into two groups: those who underwent only one corrective surgery and those who required two or more surgeries, excluding hardware removal. An age–matched analysis was conducted to ensure comparable age at most recent follow–up. Patient demographics and preoperative radiographic measurements, including Langenskiold stage, Drennan angle, mechanical lateral distal femoral angle (mLDFA), and mechanical axis deviation (MAD), were compared between groups using chi–square and Fisher's exact tests.

Results: A total of 24 patients (12 single surgery, 12 multiple surgeries) were included, with no significant difference in age at diagnosis (mean 6.2 vs. 5.9 years; p=0.74) or age at most recent follow–up (mean 12.97 vs. 13.88; p=0.56). Patients requiring multiple surgeries presented with more advanced Langenskiold stages (IV or V) than single surgery patients (72.7% vs. 18.2%; p=0.042) as well as higher preoperative Drennan angles (28.8° vs. 16.7°; p=0.019) and 100% had a preoperative MAD in zone 3, compared to only 33.3% in the single surgery group (p=0.008).

Conclusions: Patients presenting with advanced Langenskiold stage (IV or V), high pre–operative Drennan angle (mean 28.8°) and zone 3 MAD were at risk of requiring multiple corrective surgeries. Children who initially present to the orthopaedic surgeon with advanced early–onset Blount disease (Langenskiold stage IV or V, MAD in zone 3 and a high Drennan angle (mean 28.8°) may benefit from more aggressive and definitive surgical treatment to prevent recurrence of deformity and need for multiple surgeries. Definitive surgery in these patients may consist of proximal tibia and fibula osteotomy, medial hemiplateau elevation and epiphysiodesis of the proximal tibia and fibula with or without contralateral leg epiphysiodesis depending on the age of the child and family preference. These data can provide families and surgeons with realistic expectations about the surgical intervention necessary to definitely treat severe early–onset Blount Disease.

Table 1: Early-Onset Blount Disease Patient Characteristics Stratified by Number of Corrective Surgeries (excluding hardware removal).

	1 Surgery	2 or more surgeries	P Value
n	12	12	
Age at Diagnosis (mean (SD))	6.21 (2.60)	5.85 (2.75)	0.743
Age at Most Recent Follow Up (mean (SD))	12.97 (4.17)	13.88 (5.41)	0.647
Female (%)	6 (50.0)	6 (50.0)	1
Race/Ethnicity (%)			0.587
Black or African American	6 (60.0)	4 (40.0)	
Spanish/Hispanic/Latino	2 (20.0)	4 (40.0)	
Unknown	2 (20.0)	2 (20.0)	
BMI percentile (mean (SD))	97.25 (3.87)	97.20 (3.11)	0.972
Bilateral (%)	9 (75.0)	11 (91.7)	0.584
Initial Type of Treatment (%)			0.822
GG	9 (75.0)	8 (66.7)	
Osteotomy	1 (8.3)	2 (16.7)	
External Fixator	2 (16.7)	2 (16.7)	
Pre-Operative Langenskiöld Stage (%)			**0.042**
1	6 (54.5)	0 (0.0)	
2	2 (18.2)	2 (18.2)	
3	1 (9.1)	1 (9.1)	
4	1 (9.1)	6 (54.5)	
5	1 (9.1)	2 (18.2)	
Pre-Operative Drennan Angle (mean (SD))	16.72 (6.59)	28.84 (15.15)	**0.019**
Pre-Operative mLDFA (mean (SD))	92.49 (3.91)	90.72 (8.58)	0.598
Pre-Operative MAD (%)			**0.008**
1	1 (11.1)	0 (0.0)	
2	5 (55.6)	0 (0.0)	
3	3 (33.3)	10 (100.0)	

Early–Onset Blount Disease: Can We Predict Spontaneous Resolution?

Melinda Sharkey, MD; Zachariah Samuel, Ofir Horovitz, Eduardo Valero-Moreno, Taikhoom Dahodwala, Leila Mehraban Alvandi, Edina Gjonbalaj
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Early–onset Blount disease is characterized by disordered growth of the medial proximal tibial physis, often leading to progressive genu varum and early–onset osteoarthritis if left untreated. While some young patients show spontaneous resolution of the disease, many require surgery for deformity correction. Identifying predictors of spontaneous resolution could improve clinical decision making and family counseling. This study aimed to determine patient and radiographic factors associated with nonoperative resolution of early–onset Blount disease. We conducted an IRB–approved retrospective review of patients diagnosed with early–onset Blount disease between 2015 and 2024 at a tertiary care center. Patients with late–onset disease or inadequate follow–up were excluded. Demographics, Langenskiold stage (LS) and Drennan angle at diagnosis were recorded and compared between limbs that resolved without surgery and those that required operative intervention.

Results: A total of 69 limbs were included (46 operative, 23 nonoperative). Spontaneous resolution of Blount disease was noted in children who were diagnosed at a significantly younger age (2.49 vs. 4.69 years, $p<0.001$) and had lower BMI percentiles (87.34 vs. 95.43, $p=0.025$). They also had lower Drennan angles (11.12° vs. 22.65°, $p<0.001$) and a lower proportion of zone 3 MAD (43.5% vs 79.5%, $p=0.013$) at presentation. All nonoperative cases had LS I or II changes, with 73.9% presenting as LS I ($p<0.001$); no limb with LS ≥3 resolved without surgery.

Conclusions: Spontaneous resolution of early–onset Blount disease was noted in young patients (<3 years old) presenting with early–stage disease (LS I or II), lower BMI and less severe deformity (mean Drennan angle 11.1°). These findings support a conservative, observational approach in select patients (very young children < 3yo) with early–stage disease and mild deformities. Recognizing these predictive factors may help avoid unnecessary surgery and support personalized care strategies in early–onset Blount disease.

TABLE 1: Presenting Characteristics of Children Showing Spontaneous Resolution of Early-onset Blount Disease and Those Who Underwent Surgery

	Operative	Resolved Nonoperatively	P Value
n	46	23	
Age at Diagnosis (mean (SD))	4.69 (2.53)	2.49 (0.84)	**<0.001**
Years of Follow-up (mean (SD))	5.79 (3.14)	3.28 (2.91)	0.015
Female (%)	23 (50.0)	15 (65.2)	0.347
BMI percentile (mean (SD))	95.43 (10.50)	87.34 (15.33)	**0.025**
Bilateral (%)	37 (80.4)	16 (76.2)	0.942
Pre-Operative Langenskiöld Stage (%)			**<0.001**
1	8 (18.6)	17 (73.9)	
2	14 (32.6)	6 (26.1)	
3	5 (11.6)	0 (0.0)	
4	8 (18.6)	0 (0.0)	
5	8 (18.6)	0 (0.0)	
Pre-Operative Drennan Angle (mean (SD))	22.65 (10.36)	11.12 (3.48)	**<0.001**
Pre-Operative MAD (%)			**0.013**
1	1 (2.6)	3 (13.0)	
2	7 (17.9)	10 (43.5)	
3	31 (79.5)	10 (43.5)	

Predicting Success of Growth Modulation Surgery in Late Onset Tibia Vara (LOTV)

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Question: Growth modulation surgery with hemi−epiphyseal tether plating in LOTV has variable results in prior literature. We previously reviewed a model for predicting success of growth modulation surgery for tibia vara. Our results indicated that > 3 years of growth remaining was the single best predictor of success. However, in that study, we failed to review the effect of limb length difference (LLD) at presentation nor unilateral vs bilateral as determinants of success. This study was designed to determine the influence of those variables on success using growth modulation for tibia vara.

Answer: We retrospectively reviewed patients with late onset tibia vara treated with lateral tension band plate (LTBP) guided growth at a tertiary pediatric multi−hospital facility over a 10−year period. Pre and post operative radiographic deformity markers, implant data, and demographic data was collected. Included patients had final radiographs for analysis at minimum 2 year follow up, or last radiographs prior to hardware removal/subsequent surgery. Treatment success was defined as normalization of varus alignment or any valgus overcorrection of the limb. An ROC curve determined the optimal LLD cutoff point. Binary logistic regression models were performed to identify potential risk and treatment factors associated with successful treatments, using robust sandwich estimators to account for limb correlations in bilateral cases.

Results: 48 patients (76 limbs) met our inclusion criteria for review. 59% (45) limbs were successfully treated. An LLD of 1 cm was identified as the optimal cutoff. Compared to unilateral affected limbs, bilateral affected limbs had 3.92 times higher odds of successful treatment ($p=0.032$). Sub−analyses of unilateral and bilateral surgical limbs showed that LLD was not significantly associated with treatment success in either group.

Conclusions: In our patient cohort, bilateral limb involvement was another predictor of treatment success of LOTV with LTBP. Interestingly, LLD was not significantly associated with treatment success. This information gives helpful insight to narrow treatment indications with this technique for LOTV and provides families with better estimates of success based on preoperative risk factors. In addition to deformity magnitude and skeletal maturity, success of growth modulation surgery for LOTV was also affected by bilateral vs unilateral limb involvement. Similar to implant type, LLD did not affect success rate.

Session VI:

Award Nominated Papers I

Mitchell Bernstein, MD, Moderator

Quantifying Proximal Tibial Physeal Injury in Rigid Intramedullary Nailing in Adolescent Patients

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Question: Rigid intramedullary nailing is increasingly used to treat tibia fractures in skeletally immature patients, however the volume of injury to the proximal tibial physis and subsequent risk of abnormal growth is unknown in this patient population. The study aims to determine the volume of injury to the proximal tibial physis during rigid intramedullary nailing of the tibia in skeletally immature adolescents. This study is an important first step to quantify the volume of damage to the growth plate that occurs during opening reaming as part of the surgical technique. The results of this study will be impactful in surgical decision making for adolescent patients with tibia fractures on both a local and national scale. Furthermore, the study provides a foundation of anatomical and measurable references for future studies delineating risk of growth complications after substantial injury to the proximal tibial physis.

Answer: In this study, we measured the volume of injury to the proximal tibial physis through computer simulation modeling of rigid intramedullary nailing using a 3D modeling software (Mimics, Materialize, Inc.). We simulated the surgical technique for rigid intramedullary nailing on 3D reconstructions of Computed Tomography (CT) images from three 12 year old males with normal proximal tibias and open physes with tibial tubercle ossification stage 2. The simulation involved drilling a large–diameter opening reamer through the anterior aspect of the proximal tibial physis from a standardized starting point and trajectory, as demonstrated in Figure 1. Opening reamer diameters matched a range of those available commercially: 9.75mm, 11.0mm, and 12.0mm. We then calculated the volume of physis reamed out as a percentage of the total proximal tibial physis to determine the percent volume of injury to the physis during opening reaming, as demonstrated in Figure 2.

Results: Table 1 lists the percent volume of injury to the physis during simulated opening reaming through the proximal tibial with a 9.75mm, 11.0mm, and 12.0mm diameter reamer for three 12 year old skeletally immature males at tibial tubercle ossification stage 2 with normal CT scans of the proximal tibia. The range of injury for the 9.75mm diameter reamer was 1.92 €“ 5.55 % of the proximal tibia physis. The range of injury for the 11.0mm diameter reamer was 2.58 €“ 6.99% of the proximal tibia physis, and the range of injury for the 12.0mm diameter reamer was 3.11 €“ 8.32% of the proximal tibia physis.

Conclusions: This study demonstrates proof–of–concept for utilizing computer simulation modeling to quantify the volume of injury to the physis during rigid intramedullary nailing of adolescent tibias. This is not only an important first step in improving surgical decision–making for adolescent tibia fractures, but also provides a valuable tool for further investigating the critical threshold of physeal injury as well as growth modulation of the proximal tibia.

Figure 1. 3D computer simulation modeling of opening reamer through proximal tibia

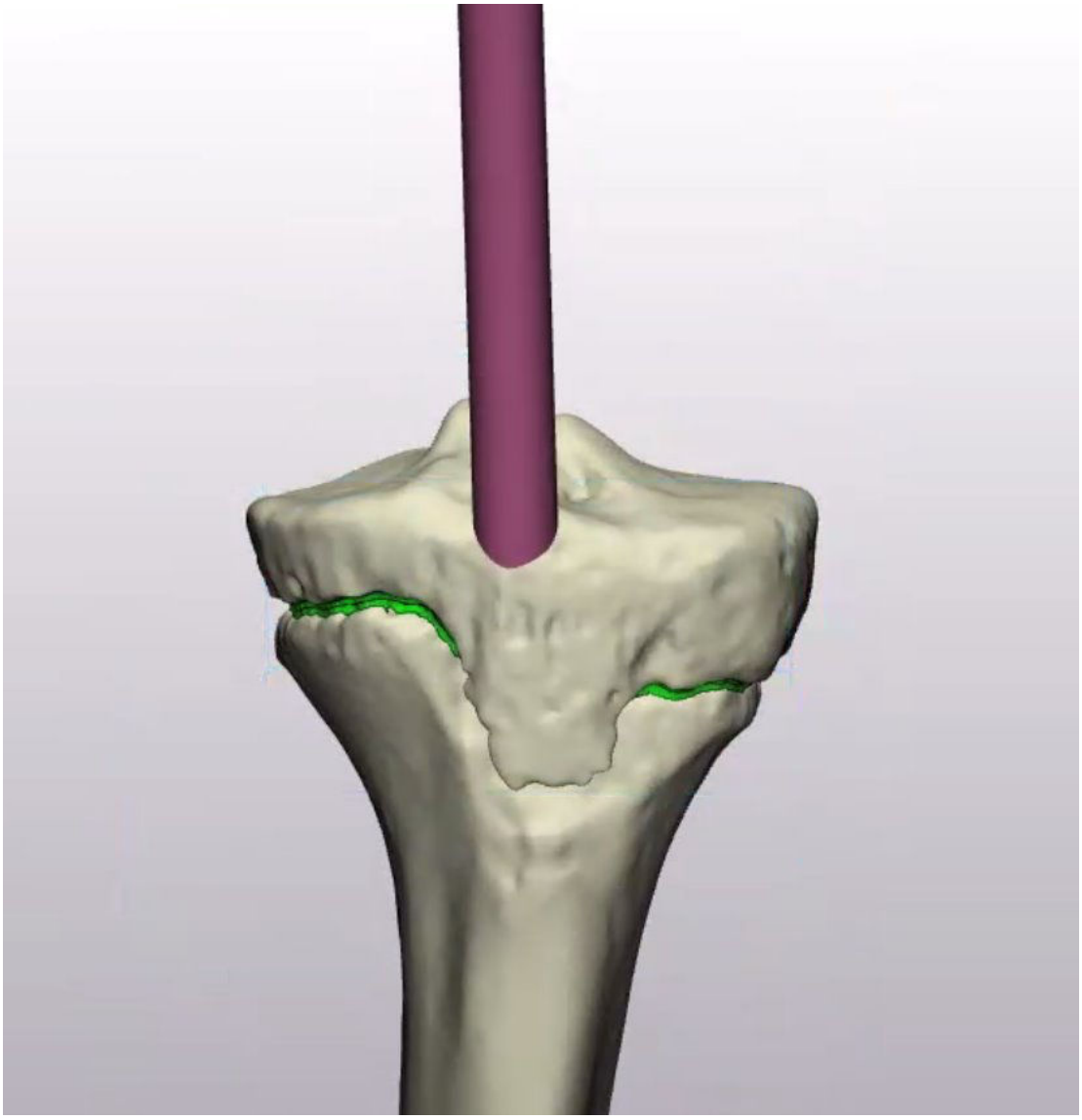

Figure 2. 3D computer simulation modeling of proximal tibia physis and opening reamer with bone subtraction

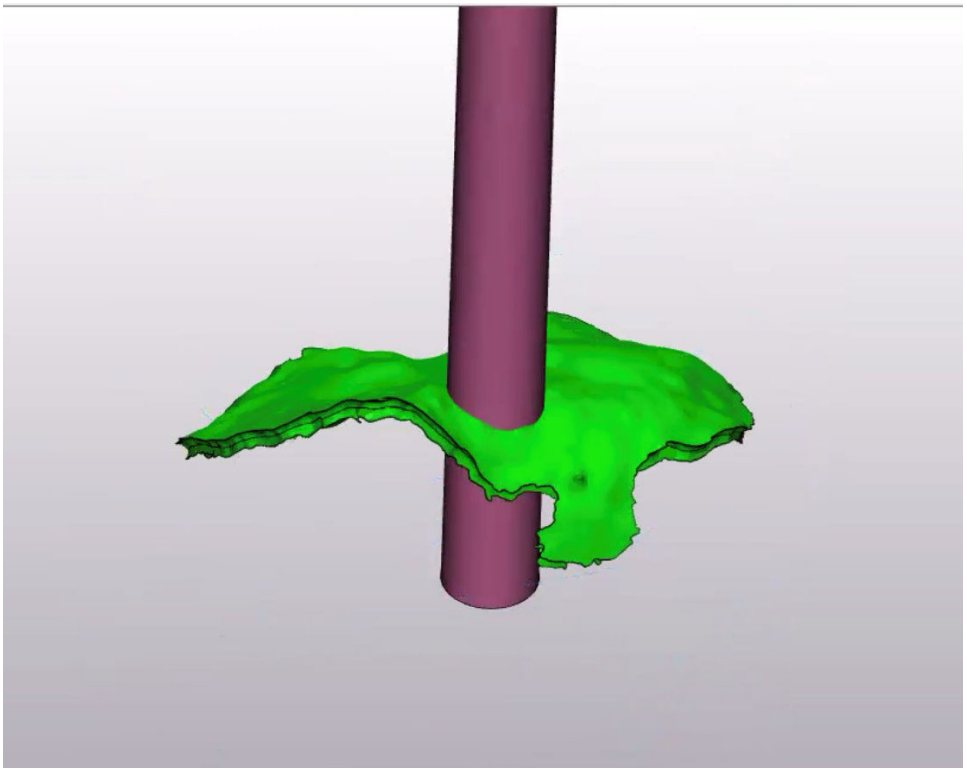

Table 1. Volume of physis injured based on opening reamer diameter

	Injured Physis Volume (mm^3)				% Physis Volume Injured		
Case	9.75mm Reamer	11.0mm Reamer	12.0mm Reamer	Total Physis Volume (mm^3)	9.75mm Reamer	11.0mm Reamer	12.0mm Reamer
1	105	137	165	5304	1.98%	2.58%	3.11%
2	149	187	223	2680	5.55%	6.99%	8.32%
3	68	88	106	2549	2.68%	3.45%	4.16%

Harnessing the Power of Nature: mRNA–Activated Biomimetic Hematoma Scaffold for Regeneration of Volumetric Muscle Loss

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Question: Volumetric Muscle Loss (VML) is a major cause of permanent disability following severe extremity injuries, often resulting from high–velocity trauma such as blast injuries, motor vehicle accidents, or muscle resections due to cancer or infection. Current treatments, including autologous muscle transplantation and rehabilitation, still frequently lead to reduced mobility and motor dysfunction, with some patients ultimately requiring limb amputation. Consequently, there is a pressing need to develop alternative approaches for VML treatment. Hematoma formation is a critical initial step in the repair of various tissue injuries, including muscle and bone, as it substantially influences tissue regeneration. Our previous studies demonstrated significant structural and biological differences between hematomas in healing and non–healing bone defects. This led to the development of a Biomimetic Hematoma (BH) scaffold, designed to mimic the fracture hematoma and serve as a delivery vehicle for growth factors. Preclinical and pilot clinical studies have shown that BH delivering rhBMP–2 effectively initiates the natural bone repair cascade, successfully regenerating large bone defects without adverse effects. Recognizing that both muscle and bone injuries initiate with hematoma formation, we hypothesized that in large muscle defects, similar to bone defects, the hematoma may become diluted, resulting in inadequate clot formation and impaired healing. Thus, this study aimed to explore the potential of the BH scaffold as a delivery vehicle for mRNA encoding Roof Plate–Specific Spondin–2 (RSPO–2), a myogenic growth factor, to promote functional regeneration of large muscle defects.

Answer: A full–thickness, 30% total area defect was created in the tibialis anterior (TA) muscle of male and female Fischer 344 rats (200–250 g). Rats were divided into three groups (n=6/group): 1) Empty Defect (ED); 2) Biomimetic Hematoma (BH) alone; and 3) 25 μg RSPO–2 mRNA+BH. An uninjured limb served as the control. Autologous blood was drawn and combined with calcium and thrombin to form a BH scaffold. In the mRNA+BH group, RSPO–2 mRNA was mixed with blood prior to creating the scaffold. Grip strength testing was used to assess functional recovery. After 4 weeks, rats were euthanized, and muscles were harvested for gross weight and histology analysis. Statistical analyses were conducted using paired sample t–tests.

Results: The ED group had increased complication rates, with one animal developing a large hematoma, four experiencing wound dehiscence, and one animal dying. In the BH and mRNA+BH groups, only one case of wound dehiscence occurred. On day 3, the mRNA+BH group showed no significant deficits in grip strength relative to the uninjured control, while BH and ED groups had notable deficits. TA muscle weights in the BH and mRNA+BH groups did not differ significantly compared to uninjured limbs; however, the ED group had significantly lower TA weights. At 4 weeks, gross inspection revealed that muscles in the BH and mRNA+BH groups closely resembled the uninjured controls. Histological analysis showed residual scar tissue in the ED group, while the regenerated muscle in BH and mRNA+BH groups demonstrated morphology and revascularization similar to the uninjured limb.

Harnessing the Power of Nature: mRNA–Activated Biomimetic Hematoma Scaffold for Regeneration of Volumetric Muscle Loss *continued*

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Conclusions: This preliminary study demonstrates that an autologous BH scaffold, alone or with RSPO–2 mRNA, effectively regenerated VML in a rat model within 4 weeks. The BH alone group showed no morphological difference from the uninjured limb at 4 weeks, while RSPO–2 mRNA restored grip strength more rapidly than BH alone. In contrast, only fibrotic tissue was observed in the ED group, indicating impaired healing. This study is the first to use an autologous BH scaffold that mimics the properties of a naturally healing muscle hematoma. Further research may lead to a promising autologous treatment approach for functional muscle defect regeneration in clinical settings.

Normative Proximal Tibial Morphology Through Childhood and Implications for Deformity Analysis and Correction

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Question: Knee deformities in the pediatric population are a significant clinical concern and can lead to joint degeneration and functional impairment if left untreated. Osteotomies can restore alignment in knee deformities but require an accurate understanding of normal morphology. Skeletal dysplasias and Blount's disease, in particular, involve abnormal physeal growth, leading to asymmetric tibial plateau development, which can cause significant limb deformity. The decision to perform accurate corrections such as guided growth or hemiplateau osteotomy requires precise understanding of normal tibial morphology. While adult morphologic data exists, comprehensive pediatric data is lacking. This study aims to define normative age based values for pediatric tibial morphology to enhance the precision and outcomes of pediatric deformity analysis and correction.

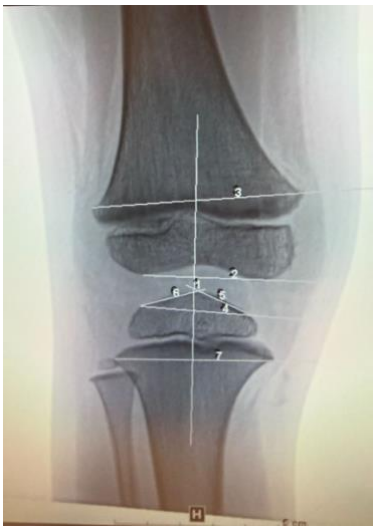
Answer: Proximal tibial morphology was measured on radiographs in male patients aged 24 months to 18 years who underwent knee or tibia/fibula X−rays from 2005 to 2022 by three of the authors. Exclusion criteria included fractures about the knee, genetic disorders, skeletal dysplasia, prior tibial fractures, osteomyelitis, tibial surgery, or inadequate X−rays. Radiographs were deemed adequate if on the anteroposterior (AP) radiograph, the patella was central, and there was tibia−fibula overlap (less than 50%). On the lateral radiographs, adequate was defined as the medial and lateral condyles and plateaus being superimposed, and there being tibia−fibula overlap. On the AP, the tibial shaft was used as a reference line, and angles were measured from the femoral condyles, femoral physis, tibial plateau, medial plateau, lateral plateau, and tibial physis (Figure 1). On the lateral radiograph, the tibial shaft was the reference with angles measured from the tibial plateau, tibial physis, and fibular shaft (Figure 2). Statistical analyses included means, standard deviations, t−tests, and Spearman Ranked Correlation Coefficients.

Results: X rays from 97 male patients were analyzed. Tables 1 and 2 demonstrate the means and standard deviations for AP and lateral X rays, respectively. Spearman's correlations showed strong associations between age and lateral/medial plateaus ($p = 0.968$), femoral physis/condyles ($p = 0.670$), and moderate association for tibial physis/plateau ($p = 0.503$), with all having a p−value less than 0.0001.

Conclusions: This study establishes normative, age−based values for male proximal tibia morphology to provide guidance for deformity analysis and correction. As the first study of its kind, this has the potential to improve precision in surgical planning. We intend to continue analysis to expand our sample size and include female patients to look at gender−based differences. We will analyze intra−observer reliability by remeasuring select subjects at four different time points over six months. Another future direction of the study will be analyzing proximal tibia morphology by chronological age as compared to skeletal maturity using the Fels Knee Skeletal Maturity System.

Figure 1

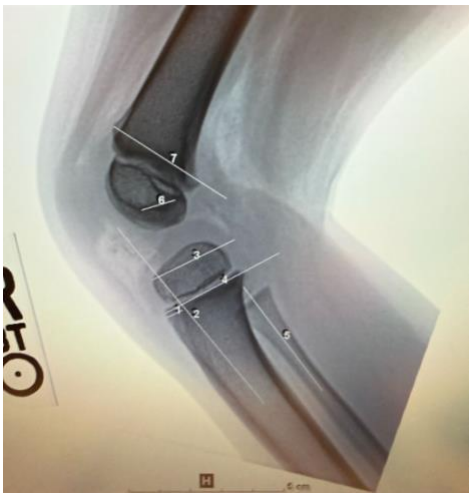
AP Radiograph with Sample Measurements



Line 1 represents the reference line drawn from the center of the tibial shaft to the center of the knee. Line 2 is the femoral condylar axis. Line 3 is the femoral physeal line measured from the metaphyseal flare. Line 4 is the tibial plateau measured from the flattest point medial and lateral. Line 5 is the slope of the medial plateau. Line 6 is the lateral plateau. Line 7 is the tibial physis. All angles were measured medially except the lateral plateau

Figure 2

Lateral Radiograph with Sample Measurements



Line 2 is the reference line drawn from the anterior 1/5 of the proximal tibial metaphysis centered distally on the shaft. Line 3 is the tibial slope. Line 4 is the physeal slope. Line 5 is the fibular shaft. All angles were measured posteriorly.

Table 1-AP Measurements

Age	n	Femoral Condyles	±SD	Femoral Physis	±SD	Tibial plateau	±SD	Medial Plateau	±SD	Lateral Plateau	±SD	Tibial Physis	±SD
2	9	98.11	2.8	97.46	2.28	91.30	2.74	63.19	2.11	58.61	3.37	94.35	1.87
3	10	94.65	2.3	97.90	2.4	90.95	2.0	62.93	3.5	63.32	6.0	94.58	1.2
4	10	92.38	2.8	96.03	2.4	91.13	2.7	63.05	3.4	64.53	3.7	93.22	2.1
5	10	89.63	1.1	95.35	1.01	90.48	1.7	66.08	3.1	67.57	3.5	93.09	1.6
6	4	91.50	0.6	96.75	1.6	91.29	1.6	64.21	2.8	65.04	4.3	93.29	2.8
7	6	90.64	1.3	97.39	1.9	91.53	1.3	70.08	3.1	72.58	2.7	93.67	1.5
8	1	90.33		100.00		91.50		71.00		70.83		93.67	
9	4	88.96	1.3	95.33	1.1	90.71	1.2	72.46	2.4	72.67	1.9	90.88	0.9
10	5	87.90	1.0	93.97	1.5	89.50	0.4	72.10	2.7	74.17	1.9	91.93	1.4
11	7	89.93	1.0	94.98	1.8	90.26	0.9	75.38	4.2	74.62	1.7	92.81	2.1
12	6	88.56	1.0	93.92	3.4	89.28	1.3	75.67	1.6	76.83	1.6	94.03	3.1
13	10	89.94	2.0	94.21	2.3	90.34	1.5	75.64	3.0	75.36	2.9	93.29	2.8
14	6	88.19	1.6	92.76	1.0	89.24	1.4	77.42	3.1	79.14	3.3	93.53	1.2
15	5	86.37	1.7	92.47	2.0	88.50	1.0	75.07	3.0	80.73	3.2	93.53	2.4
16	3	87.72	0.8	90.22	1.3	88.28	1.6	76.17	1.9	79.28	0.7	92.22	0.6
17	1	87.75		93.5		89.67		76.33		79.83		89.83	

All measurements reported as means using tibial shaft as reference line. N=number of subjects analyzed, SD=standard deviation

Table 2- Lateral Measurements

Age	n	Tibial Physis	±SD	Tibial plateau	±SD	Fibular Shaft	±SD
2	9	81.06	2.1	84.30	2.6	2.20	1.3
3	10	83.13	2.0	84.29	1.7	2.49	0.8
4	10	77.62	2.0	80.99	2.5	2.18	0.9
5	10	77.83	2.0	80.90	2.6	3.53	1.1
6	4	76.67	2.5	80.83	2.3	3.71	1.6
7	6	80.50	3.1	82.02	3.7	3.71	2.1
8	1	74.50		76.00		1.00	
9	4	76.29	2.1	78.50	2.7	4.33	1.9
10	5	76.37	1.9	82.03	1.8	2.67	0.8
11	7	76.26	3.6	78.95	2.8	2.83	1.2
12	6	77.39	2.6	80.69	2.5	3.00	1.5
13	10	77.95	2.7	81.38	2.7	3.24	1.9
14	6	79.22	2.5	81.67	3.3	2.46	0.9
15	5	77.60	3.5	80.70	2.6	0.95	0.6
16	3	77.44	2.1	78.89	1.5	2.61	0.9
17	1	73.83		77.17		2.67	

All measurements reported as means using tibial shaft as reference line. N=number of subjects analyzed, SD=standard deviation

Can the Addition of a 3D−Painted Bone Scaffold Accelerate the Maturation of Regenerate Bone During Distraction Osteogenesis in a Lapine Model? A Pilot Study

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Question: Since the duration of distraction osteogenesis treatment can last months, finding a method to accelerate bone healing would be clinically valuable. Biologics and biomaterials have been used to manage bone defects. There is growing interest in their role in increasing the regenerate bone's maturation rate during limb lengthening. Hyperelastic bone™ composed of 90% hydroxyapatite (HA) and 10% polylactic co−glycolic acid (PLGA), is a 3D−printed bone graft substitute that has been used to reconstruct bone defects. Our hypothesis was that supplementing the distraction osteogenesis process with 3D−printed Hyperelastic Bone™ could accelerate the maturation of the regenerate bone in a limb−lengthening rabbit model.

Answer: Following IACUC approval, nine New Zealand white rabbits were included in this study. They were divided into three groups: one control group where lengthening occurred without the use of 3D−printed Hyperelastic bone™, and two study groups using two different 3D−printed (0.8mm inter−fiber spacing 6 x stacking) Hyperelastic bone™ morphologies. The Hyperelastic bone™ sheet was laid directly on the bone under the periosteum at the osteoplasty site prior to wound closure for both study groups. For study group 1, the Hyperelastic bone consisted of 10% PLGA and 90% calcium phosphate (hydroxyapatite). For Study Group 2, 20% of the hydroxyapatite content was replaced with Beta−Tricalcium Phosphate to create a Biphasic Hyperelastic bone™. All animals had surgery on the left tibia. A mini−rail linear external fixator was applied to the left tibia and distracted at a rate of 0.75 mm per day, divided into three increments of 0.25 mm. Each tibia was lengthened by 20% of its original length. Plain X−rays were carried out weekly during the distraction phase and fortnightly during the consolidation phase. Necropsy was carried out after 8 weeks of consolidation, during which the tibia was harvested. Harvested specimens underwent micro−CT imaging of the regenerate bone area for quantitative analysis.

Results: There was regenerate bone visible in the distraction gap on plain x−rays by the 2nd–3rd week in all groups. All groups achieved satisfactory corticalization of the regenerate by the end of the consolidation period. Micro−CT analysis revealed that both experimental study groups had higher bone volume (BV) and total volume (TV) compared to the control group. The biphasic Hyperelastic bone™ group had higher bone volume and total volume compared to the traditional Hyperelastic bone, although this was not statistically significant. The biphasic group also had higher bone mineral density values compared to the control and traditional Hyperelastic bone™ groups.

Conclusions: This pilot study is the first to evaluate the qualitative and quantitative properties of regenerate bone formed during distraction osteogenesis in a rabbit tibial model that was supplemented with a 3D printed scaffold. Although not statistically significant, the Biphasic Hyperelastic bone™ produced better results compared to the traditional Hyperelastic bone™ and the control group during distraction osteogenesis.

Can the Addition of a 3D−Painted Bone Scaffold Accelerate the Maturation of Regenerate Bone During Distraction Osteogenesis in a Lapine Model? A Pilot Study
continued

Christopher A. Iobst, MD; Anirejuoritse Bafor, MD; Benjamin Brooks, Sara Mcbride-Gagyi, Daryn Strub
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The promising results of this study indicate that there may be a role for bone scaffolds in distraction osteogenesis. Additional research to refine the optimal scaffold shape and design should be performed in an attempt to further accelerate the regenerate bone maturation process.

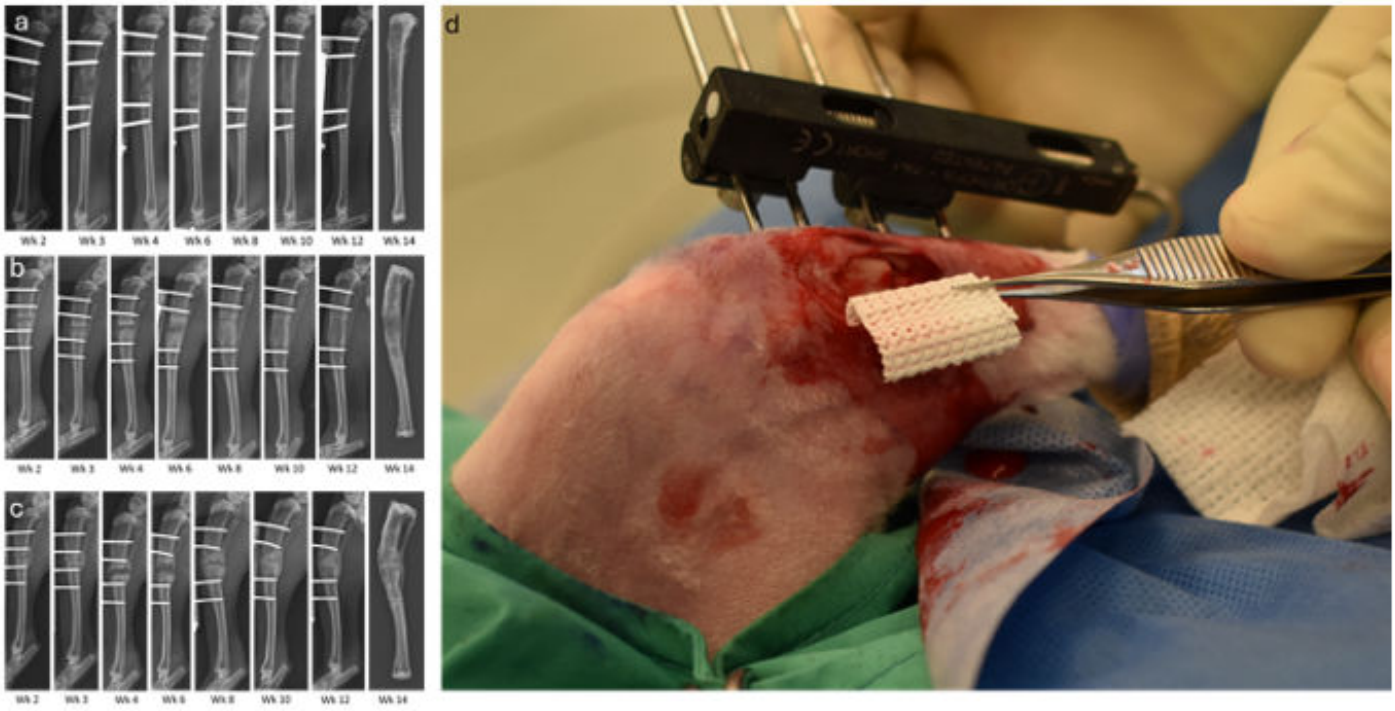

Figure 1. Serial radiographs during the distraction and consolidation phases. **A**) Control group (no Hyperelastic Bone). **B**) Study group 1 (Hyperelastic Bone – Hydroxyapatite with 0.8mm interfiber spacing, 6 x stacking morphology, containing 10% PLGA, 90% Calcium Phosphate, and 100% Hydroxyapatite). **C**) Study group 2 (Hyperelastic Bone – Biphasic with 0.8mm interfiber spacing 6 x stacking morphology, containing 10% PLGA, 90% Calcium Phosphate and 80% Hydroxyapatite +20% Beta-Tricalcium Phosphate). **D**) Picture showing intraoperative use of Hyperelastic bone.

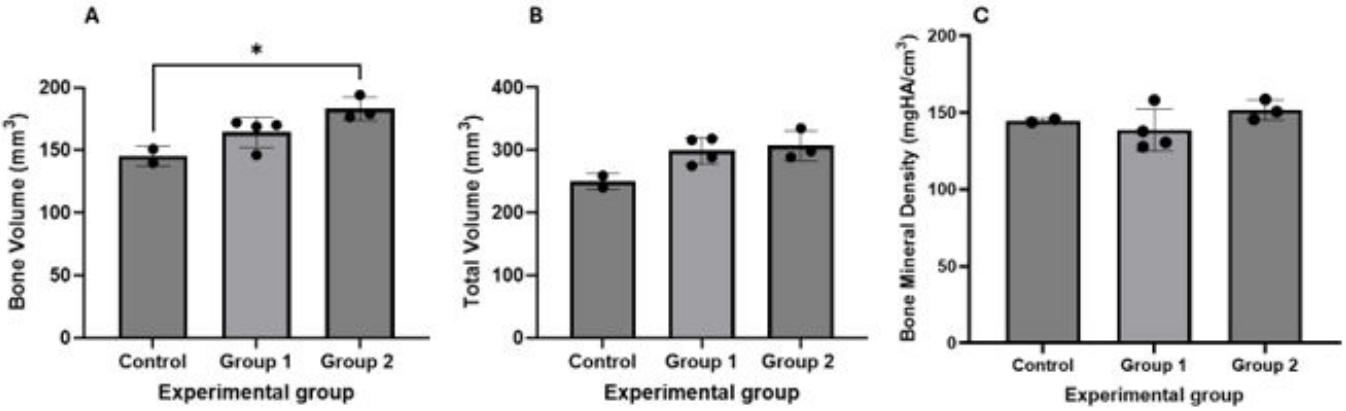

Figure 2. Quantitative micro-CT assessment of the regenerate bone following 20% lengthening of the left tibia in a rabbit external fixator lengthening model in a Control group (no Hyperelastic Bone), Study group 1 (Hyperelastic Bone – Hydroxyapatite with 0.8mm interfiber spacing, 6 x stacking morphology, containing 10% PLGA, 90% Calcium Phosphate, and 100% Hydroxyapatite) and Study group 2 (Hyperelastic Bone – Biphasic with 0.8mm interfiber spacing 6 x stacking morphology, containing 10% PLGA, 90% Calcium Phosphate and 80% Hydroxyapatite +20% Beta-Tricalcium Phosphate). **A**) Bone volume comparison. **B**) Total volume comparison. **C**) Bone mineral density comparison.

Effect of Distraction Osteogenesis on Body Weight − An Experimental Study in a Lapine Model

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Question: Major surgery has been reported to affect body weight to different degrees. Anecdotally, weight loss has been reported following limb lengthening surgery. This has been attributed to a loss of appetite and an increased caloric need as distraction osteogenesis places a significant anabolic demand on the body. We sought to determine the pattern of weight change during limb lengthening. We hypothesized that during the distraction phase of treatment, body weight would decrease due to an increase in metabolic demand as osteogenesis progressed.

Answer: Following IACUC approval, we performed unilateral lengthening of the left tibia in nine New Zealand White rabbits aged 3 months. Throughout the study, the rabbits received equal amounts of food daily, supplemented with additional nutritional enrichments. The rabbits weighed between 3.15 and 3.4 kg at the time of surgery. The tibia was lengthened at a rate of 0.75 mm per day in 3 divided adjustments of 0.25 mm each until the tibia was 20% longer than its initial length. They were weighed on days 0, 21, 28, 35, 49, 63, and 77.

Results: The mean weight for the group on arrival was 3.27 kg. This dropped to a mean weight of 3.15 kg by day 35, which corresponded to the end of the distraction period. This represents a 3.7% loss of starting body weight. Following this, there was a steady increase in weight, achieving a mean weight of 3.41 kg on day 77. The R2 value was 0.9733. The progression of the weight change is represented in the figure below.

Conclusions: Our findings suggest that during the distraction phase of bone lengthening, weight loss occurs, which is typically recovered during the consolidation phase of treatment. These findings indicate that optimizing nutrition, perhaps with the addition of supplements, should be considered during the distraction phase of limb lengthening.

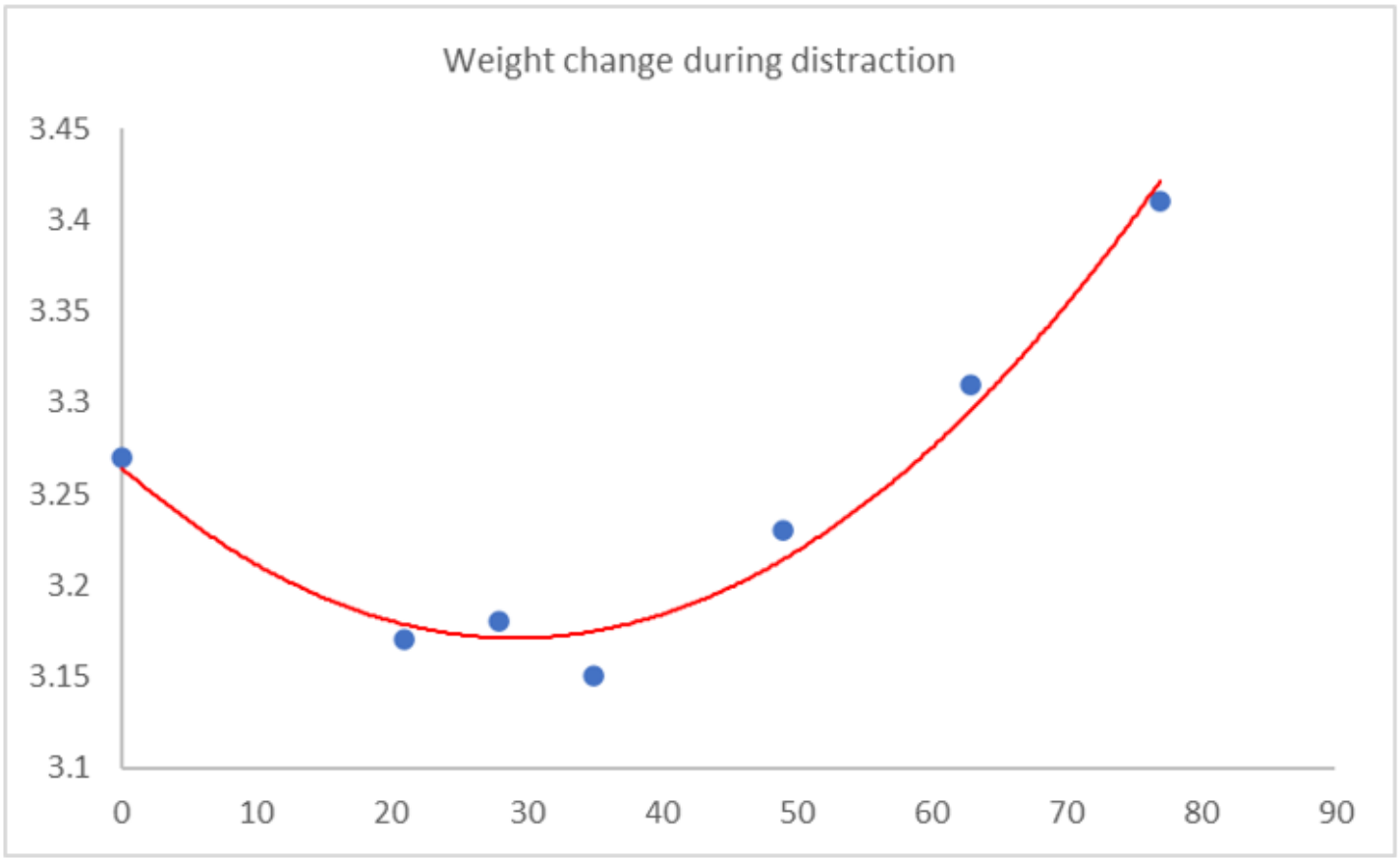

Figure. Pattern of change in weight over time during lengthening of rabbit tibiae.

Alessandro Codivilla Guest Speaker

Achieving Excellence

Blake Leeper

Blake Leeper was born in Kingsport, Tennessee with both legs missing below the knee, and has worn prosthetics since nine months of age. In his childhood, Blake participated in various sports, baseball, basketball etc. with his dad coaching. Blake credits his outstanding positive attitude to his family.

Leeper made his international debut in 2009 at Rio de Janeiro. In 2011 he won a silver medal in the World Championships 4 × 100 m Relay . In the 2012 Paralympic Games, he won an individual silver medal in the 400 meter T44 event and a bronze medal in the 200m Blake Leeper made history by becoming the first double-leg amputee to compete at the USATF National championships! After qualifying for semifinals with a time of 45.52 seconds in the 400m, Leeper was able to break Oscar Pistorius' world record in the event with a time of 45.25 seconds the next day. In 2018 he shattered his own word record running a time of 44.42 secs becoming the first ever amputee to run under 45 seconds! in 2019 he broke another World Record in the 400m with a time of 44.38 seconds at the USATF National Championships. Making history again by being the first amputee ever qualifying for the national team and world championships. Blake ran the 6th fastest time in the world this year, that also includes able bodied runners.

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https://www.instagram.com/leepster/

https://www.youtube.com/watch?v=c4PTYR5GRA8&t=2s

Traveling Fellowship Presentation

Introduction by Jaclyn F. Hill, MD

Caleb Gottlich, MD
Saad Malik, MD
Mike Russell, MD
Ashley Startzman, MD
Bicheng Yong, MD

Session VII:

Award Nominated Papers II

Jill C. Flanagan, MD, Moderator

Compounding Pulleys: Automated Multifocal Cable Bone Transport for Segmental Tibial Defects Using a Single Head Unit

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Question: Cable bone transport is a promising technique to manage segmental tibial bone defects. Using an internal cable allows for bone transport without the burden of pins or wires dragging the soft tissue envelope locally. This technique has gained popularity for its ability to minimize soft tissue compromise, enhance patient comfort and improve overall outcomes.

The integration of automated hexapod struts into cable bone transport systems represents a significant advancement in the treatment of segmental tibial defects. Automated struts enable precise, incremental adjustments during bone transport, improve alignment control and reduce the reliance on patient compliance. Multifocal bone transport can be challenging in automated setups. We developed a technique to leverage a compound pulley in order to control multiple bone transport segments using a single head unit, thus reducing complexity of the fixator and programming. Our research question was: Is the use of a compound pulley during automated balanced cable transport for segmental tibial defects effective?

Answer: A prospective cohort at a single Level 1 trauma center was performed. All adult patients with segmental tibia defects undergoing multifocal bone transport were included in this cohort. Demographic data, as well as defect size, fixator details, and complications were prospectively collected.

Results: A total of 10 patients underwent multifocal bone transport and are docked at the time of our submission. 70% of the patients were mail. The average age was 49 (29–70 years). The external fixator was setup to be an antegrade trifocal tibia to ankle fusion in 3 patients, antegrade trifocal tibial shaft in 3 patients, retrograde trifocal tibia shaft in 2 patients, antegrade tetrafocal in 1 patient, and diverging tetrafocal in 1 patient. The average defect size was 8.2 cm (7.2–11 cm). The average frame index was 10.1 days/cm (7.3–17.1 days/cm). The headunit had a malfunction in 2 cases that require reprogramming during a clinic visit. All patients successfully docked and were converted to internal fixation after docking.

Conclusions: A compound pulley setup is an effective solution to simplify automated balanced cable bone transport for tibial defects. This allows the surgeon to set up multiple cables and drive the transport using a single head unit. We encountered spontaneous head unit malfunction in 2 cases, which required reprogramming in clinic and continuation of transport without further complications.

Comparative Outcomes of 8.5mm Intramedullary Nails versus Extramedullary Constructs for Femoral Lengthening in Pediatric Patients

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Question: Limb−length discrepancies (LLDs) have traditionally been treated with external fixators, but magnetically driven intramedullary nails (MILNs) are increasingly favored for improved comfort and reduced infection risk. This study compared intramedullary (IM) versus extramedullary (EM) lengthening nails in pediatric patients with narrow femoral canals to evaluate mechanical axis deviation, nail bending, tourniquet time, and complications.

Answer: A retrospective, single−center review was conducted of 75 pediatric patients who underwent femoral lengthening between 2005 and 2022, each with at least two years of follow−up. Patients received either an 8.5 mm IM nail or a 10.7/12.5 mm EM nail. Outcomes included pre− and postoperative limb alignment (MAD, LDFA, PDFA), nail bending, operative details (tourniquet time, blood loss), consolidation times, and complication rates classified according to the Cherkashin system.

Results: Forty−two patients were treated with EM nails and 33 with IM nails. Both groups achieved similar distraction amounts (4.7 ± 1.1 cm) and consolidation intervals (7−8 months). However, the EM group demonstrated significantly greater postoperative MAD (12.9 ± 9.5 mm vs 8.7 ± 7.3 mm, $p<0.05$), higher nail bending (2 vs1.2, $p<0.05$), and longer tourniquet use. Overall complication rates were 69% (EM) and 60% (IM), with delayed union and soft−tissue infection being the most frequent issues. Unplanned reoperations occurred in 21% of patients overall.

Conclusions: In patients with narrow femoral canals, 8.5 mm IM nails resulted in fewer mechanical deviations than EM implants. Careful implant selection, moderate distraction goals, and vigilant postoperative follow−up appear crucial to minimizing complications and improving lengthening outcomes.

To Correct or Overcorrect − That is the Question: Rates of Deformity Recurrence in Surgically Treated Early−Onset Blount Disease

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Question: A foundational principle in the successful surgical treatment of early−onset Blount Disease is that overcorrection of the tibia to a valgus alignment is critical for disease resolution. However, the level of overcorrection, regardless of surgical method, required to prevent recurrence remains unclear. This study aimed to determine the ideal amount of valgus alignment needed to minimize the risk of recurrence of varus deformity.

Answer: An IRB−approved retrospective review was conducted on patients with surgically treated early−onset Blount Disease between 2015 and 2024 at a tertiary care center. Mechanical axis deviation (MAD) was measured after initial osteotomy surgery (for acute corrections) and just prior to guided growth plate removal (for gradual corrections) and patients were separated into three groups: those obtaining MAD −1 (mild valgus), those obtaining MAD −2 or −3 (moderate/severe valgus), and those under corrected to MAD 1, 2, or 3 (residual varus). The primary outcome was recurrence of varum (MAD 2 or 3) at most recent follow−up and secondary outcomes included Langenskiold resolution at most recent follow−up and the number of corrective surgeries.

Results: Thirty−seven limbs were included and of these 17 limbs obtained some degree of valgus over−correction while 20 were left in neutral alignment or in some degree of varus deformity. Of those limbs obtaining valgus alignment, 10 had MAD −1 alignment (mild valgus) and 7 were overcorrected to MAD −2 or −3 (moderate/severe valgus). No significant differences were noted in most recent MAD, rate of recurrence or Langenskiold stage at most recent follow−up in the over−corrected patients regardless of degree of over−correction. After combining the overcorrected limbs (MAD −1, −2 or −3), one (7.7%) showed recurrence, compared to nine (47.4%) under−corrected limbs (MAD 1, 2 or 3) (p=0.047). The mean number of corrective surgeries was lower in the overcorrected group (1.24 vs. 1.55; p=0.167). All patients with over−correction to valgus alignment were treated with guided growth, versus 60% in the under−corrected group (p=0.013).

Conclusions: While valgus overcorrection may not completely prevent genu varum recurrence, it can significantly reduce the rate of varus recurrence, increase the rate of Langenskiold stage resolution, and lower the need for revision surgeries. Surprisingly, 52.6% of the 20 under−corrected limbs achieved neutral or valgus alignment at most recent follow−up, indicating that positive outcomes are possible despite initial under correction. This study provides further evidence of the importance of obtaining some degree of valgus lower extremity alignment to decrease the rate of revision surgery for early−onset Blount Disease patients.

Table 1: Results of Mild vs Moderate/Severe Valgus Over-Correction in the Surgical Treatment of Early-Onset Blount Disease

	Overcorrected to -1	Overcorrected to -2 or -3	P value
N	10	7	
Age at Diagnosis (mean (SD))	5.10 (1.86)	3.21 (2.26)	0.078
Years of Follow-up (mean (SD))	4.88 (1.91)	4.76 (2.15)	0.9
Female (%)	7 (70.0)	4 (57.1)	0.976
Race (%)			0.186
Black or African American	5 (50.0)	3 (42.9)	
Not Black or African American	5 (50.0)	2 (28.6)	
Unknown	0 (0.0)	2 (28.6)	
Ethnicity (%)			0.529
Not Spanish/Hispanic/Latino	4 (40.0)	3 (42.9)	
Spanish/Hispanic/Latino	5 (50.0)	2 (28.6)	
Unknown	1 (10.0)	2 (28.6)	
BMI Percentile (mean (SD))	90.60 (15.51)	96.77 (2.09)	0.317
Bilateral (%)	10 (100.0)	5 (71.4)	0.301
Preoperative Langenskiold Stage			0.142
I	4 (40.0)	0 (0.0)	
II	2 (20.0)	3 (42.9)	
III	1 (10.0)	1 (14.3)	
IV	2 (20.0)	0 (0.0)	
V	1 (10.0)	3 (42.9)	
Preoperative MAD			0.651
1	1 (11.1)	0 (0.0)	
2	2 (22.2)	1 (16.7)	
3	6 (66.7)	5 (83.3)	
Most Recent Drennan Angle (mean (SD))	15.87 (27.64)	9.05 (6.07)	0.603
Most Recent mLDFA (mean (SD))	90.74 (1.97)	89.24 (2.99)	0.301
Most Recent mMPTA (mean (SD))	89.80 (2.81)	85.36 (3.79)	0.052
Varus at Most Recent Follow Up (%)	0 (0.0)	1 (16.7)	0.936
Langenskiold Resolution (%)	6 (60.0)	5 (71.4)	1
Number of Corrective Surgeries (mean (SD))	1.30 (0.67)	1.14 (0.38)	0.587

Table 2: Valgus Over-Correction vs Under-Correction (residual neutral or varus alignment) in Early-Onset Blount Disease

	Corrected to Valgus MAD -1, -2, or -3	Under-corrected to MAD 1, 2, or 3	P value
N	17	20	
Age at Diagnosis (mean (SD))	4.32 (2.19)	5.10 (2.82)	0.361
Years of Follow-up (mean (SD))	4.83 (1.95)	6.35 (2.94)	0.079
Female (%)	11 (64.7)	6 (30.0)	0.075
Race (%)			0.775
Black or African American	8 (47.1)	11 (55.0)	
Not Black or African American	7 (41.2)	6 (30.0)	
Unknown	2 (11.8)	3 (15.0)	
Ethnicity			0.569
Not Spanish/Hispanic/Latino	7 (41.2)	11 (55.0)	
Spanish/Hispanic/Latino	7 (41.2)	5 (25.0)	
Unknown	3 (17.6)	4 (20.0)	
BMI Percentile (mean (SD))	93.14 (12.11)	95.75 (11.25)	0.502
Bilateral (%)	15 (88.2)	17 (85.0)	1
Initial Treatment (%)			**0.013**
Guided Growth	17 (100.0)	12 (60.0)	
Osteotomy +Acute Correction	0 (0.0)	5 (25.0)	
Osteotomy + Gradual Correction	0 (0.0)	3 (15.0)	
Preoperative Langenskiold Stage			0.596
I	4 (23.5)	4 (22.2)	
II	5 (29.4)	7 (38.9)	
III	2 (11.8)	2 (11.1)	
IV	2 (11.8)	4 (22.2)	
V	4 (23.5)	1 (5.6)	
Preoperative MAD			0.508
1	1 (6.7)	0 (0.0)	
2	3 (20.0)	3 (16.7)	
3	11 (73.3)	15 (83.3)	
Most Recent Drennan Angle (mean (SD))	13.25 (21.68)	13.54 (7.56)	0.963
Most Recent mLDFA (mean (SD))	90.05 (2.51)	91.66 (5.81)	0.358
Most Recent mMPTA (mean (SD))	87.78 (3.88)	85.13 (7.91)	0.321
Varus at Most Recent Follow Up (%)	1 (7.7)	9 (47.4)	**0.047**
Langenskiold Resolution (%)	11 (64.7)	8 (44.4)	0.388
Number of Corrective Surgeries (mean (SD))	1.24 (0.56)	1.55 (0.76)	0.167

Treatment Outcomes Following Retrograde Femoral Extramedullary Lengthening Using an Internal Lengthening Nail

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Question: Whenever possible, internal lengthening nails have replaced external fixators as the primary device for lengthening long bones. However, there are situations, such as small patients or very young patients, where placing the internal lengthening nail in an intramedullary location is either not safe or not possible due to the limited implant sizes. In these situations, it may be possible to use the internal lengthening nail in an extramedullary location. We have been using a retrograde extramedullary femoral technique without supplemental internal fixation in our patients since 2018. The purpose of this study was to review the outcomes in patients undergoing retrograde femoral extramedullary lengthening.

Answer: We conducted a retrospective chart review of patients who underwent limb−lengthening procedures using an extramedullary retrograde femoral lengthening nail technique. We recorded the magnitude of length discrepancy, the amount of length gained, and the bone healing index. We also reviewed the incidence of complications following this procedure. Descriptive statistics were carried out for the group. The Mann−Whitney test was used to compare gender differences.

Results: The cohort consisted of 17 patients, including 9 males and 8 females. All patients underwent femur lengthening using a magnetic lengthening nail, applied in an extramedullary, retrograde fashion, at a rate of 0.5 to 0.8 mm per day. The mean age for male and female patients was 6.2 ± 1.9 years and 8.0 ± 2.4 years, respectively. There were no significant differences in the amount of length discrepancy present, the amount and percentage of lengthening done, or the bone healing index. (see Table) Three patients developed aseptic bursal fluid collections within the soft tissue around the distal end of the nail. No patient developed complications related to the regenerate bone (deformity or fracture). No patients required a return trip to the operating room and no patients developed contractures of the hip or knee requiring intervention other than conventional therapy or bracing. Patients were followed up for an average of 23 months.

Conclusions: Retrograde extramedullary lengthening of the femur using an internal lengthening nail has been demonstrated to be a safe and effective method of lengthening the femur in young patients as an alternative to using an external fixator. By using the implant in a retrograde fashion, no supplemental internal fixation was required, and no deformities of the regenerate bone were noted. Therefore, retrograde extramedullary femoral lengthening using an internal lengthening nail is a viable alternative to external fixator lengthening in young, skeletally immature patients when intramedullary placement of the nail is not possible.

Table. Summary of patient demographics and results of the extramedullary lengthening procedure.

	Male	Female	P value
Age (years)	6.2 ± 1.9	8.0 ± 2.4	0.1270
LLD (cm)	5.3 ± 1.7	9.4 ± 5.3	0.0673
Length gained (cm)	3.6 ± 0.5	3.9 ± 0.6	0.4275
% length gained	14 ± 3.8	15 ± 3.3	0.9781
Bone healing index (days/cm)	32 ± 8.1	32 ± 7.3	0.6730

Is There a Negative Correlation between Screw Length and Correction Rate via Guided Growth? A Retrospective Study of 138 African Limbs with Genu Varum

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Question: The purpose of this study was to identify factors that contribute to the speed of angular correction in skeletally immature patients with genu varum treated with paraphyseal tension band plates. Specifically, the study hypothesized that screw length and divergence, severity of deformity, and underlying pathology would influence the rate and speed of genu varum correction.

Answer: This retrospective study reviewed 53 patients under 18 years with genu varum treated in Malawi, Africa with guided growth (GG) using 2−hole semi−tubular plates (2020−2022). Inclusion criteria included radiographic diagnosis and ≥6 months of follow−up. Patients were categorized by age (<8 vs. >8 years) and etiology (idiopathic vs. non−idiopathic). Standardized surgical technique allowed immediate weight−bearing. Radiographic assessments were performed preoperatively, every 3 months, and at final follow−up. Deformity severity, correction speed, and screw parameters were analyzed using STRADUS. Statistical analysis (R software) included t−tests, ANOVA, and regression models, with significance at $P<0.05$.

Results: This study identified key factors influencing the speed of angular correction in skeletally immature patients with genu varum treated with guided growth. (See Figure and Table) Screw length was inversely correlated with correction rate ($P<0.001$); shorter screws (75% of physis width, 0.93°/month). Deformity severity also negatively impacted correction speed ($P<0.001$). Age was a significant factor, with patients <8 years correcting faster (2.03°/month) than those >8 years (0.92°/month, $P<0.001$). Etiology did not significantly affect correction speed, though metabolic disease showed the slowest rate. Tibial correction was faster than femoral correction in univariate analysis ($P<0.001$), but not in multivariate analysis. Initial screw divergence, gender, and etiology within bone groups had no significant effect. Higher BMI showed a borderline significant faster correction ($P=0.061$).

Conclusions: In our series of African patients treated with semi−tubular plates rather than commercially available tension band plates, we identified the screw length as an important parameter affecting the rate of genu varum correction with GG using paraphyseal tension band plates. Previous literature has not identified this parameter as affecting the rate of correction which may be a reflection of our patient population or the type of implant used.

Table. Univariable and multivariable linear regression analysis using the correction rate as a response

		Univariable Analysis		Multivariable Analysis	
Predictor (Rate)	Sub Group	Coefficient	P value	Coefficient	P value
Age at operation (months)		0.63 ± 0.12	<0.001*	0.004 ± 0.002	0.013*
Gender	Male	1.001± 0.092	(baseline)	-0.038±0.150	0.802
	Female	0.011± 0.164	0.946		
Body Mass Index		0.020 ± 0.010	0.061	0.016 ± 0.010	0.111
Etiology	Idiopathic	1.015± 0.106	(baseline)		
	Blount Disease	-0.009±0.201	0.966	0.230±0.180	0.202
	Osteochondrodysplasia	0.196±0.225	0.386	0.619±0.207	0.003*
	Metabolic Disease	-0.255±0.225	0.259	0.346±0.225	0.127
Initial Screw Divergence (degrees)		1.000 ± 0.008	0.968	0.006 ± 0.006	0.323
Distal Femur/Proximal Tibia	Femur	0.552±0.098	baseline	0.290±0.183	0.115
	Tibia	0.844±0.134	<0.001*		
Severity (Degrees)		-0.054±0.007	<0.001*	-0.051±0.009	<0.001*
Relative screw length (screw length/physes) (%)		-2.392 ± 0.591	<0.001*	-1.730± 0.799	<0.032

Session VIII:

Patient Reported Outcomes

Anthony Cooper, MD, Moderator

The Limb Lengthening and Reconstruction Society AIM Index: Correlations with Patient–Reported Outcome Measures in Pediatric Patients with Lower Limb Differences

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Question: The purpose of this study was to assess the reliability of the Limb Lengthening and Reconstruction Society AIM (LLRS–AIM) Index, a scale for grading the severity of lower limb deformities by the physician, and its concordance with two patient–reported outcome measures tools, the Limb Deformity–Scoliosis Research Society (LD–SRS) and Patient–Reported Outcomes Measurement Information System (PROMIS) in pediatric patients with lower limb differences.

Answer: This was a retrospective review of patients 18 years old or younger who presented to our institution with lower limb differences for surgical reconstruction between 2019 to 2024. All patients received the LD–SRS and PROMIS for completion prior to surgery. The LLRS–AIM Index for patients was assessed by two independent evaluators, with intraclass correlation coefficients (ICCs) calculated to determine interrater agreement. Spearman correlations were performed between the LLRS–AIM Index with all LD–SRS and PROMIS domains. Ceiling and floor effects were calculated as well.

Results: This study included 81 patients. The LLRS–AIM Index had good and near–perfect interrater reliability across different levels of medical training (ICC = 0.9). Overall, there were no correlations between the LLRS–AIM Index with LD–SRS and PROMIS domains (LD–SRS Pain: p = –0.06, p = 0.61; PROMIS Pain Interference: p = 0.10, p = 0.39) (Table 1). Mental health–related LD–SRS and PROMIS domains showed no correlations with the physician–reported LLRS–AIM Index (LD–SRS Self Image: p = 0.10, p = 0.39; PROMIS Depression: p = –0.05, p = 0.63). There was minimal ceiling (1.2%), but elevated floor effects for the LLRS–AIM Index (23.5%) (Table 2).

Conclusions: There is a high level of reproducibility for the LLRS–AIM Index to evaluate the complexity of lower limb differences in pediatric patients. However, there are overall no correlations between the LLRS–AIM Index with LD–SRS and PROMIS across all relevant domains. As demonstrated by its elevated floor effects, the LLRS–AIM Index may not be as sensitive in capturing complexity in patients with less severe lower limb differences. Further modifications to the LLRS–AIM Index criteria and scoring weights may be necessary to allow it to better assess patient outcomes in the pediatric population. Patient–reported outcome measures instruments' psychosocial domains should be considered in addition to the LLRS–AIM Index to help guide preoperative decision–making.

TABLE 1 - Spearman Correlations Between PROMs Domains and LLRS-AIM Index	
	LLRS-AIM Index
LD-SRS	
LD-SRS Overall	-0.10 (0.36)
LD-SRS Pain	-0.06 (0.61)
LD-SRS Function	**-0.26 (0.02)**
LD-SRS Self Image	0.10 (0.39)
LD-SRS Mental Health	0.09 (0.43)
PROMIS	
PROMIS Anxiety	-0.07 (0.52)
PROMIS Depression	-0.05 (0.63)
PROMIS Fatigue	-0.07 (0.53)
PROMIS Pain Interference	0.10 (0.39)
PROMIS Peer Relationship	-0.22 (0.05)
PROMIS Functional Mobility	-0.22 (0.05)
Data are presented as Spearman's rho (p value). Statistically significant values are bolded. PROMs indicates patient-reported outcome measures; LD-SRS, Limb Deformity-Scoliosis Research Society; PROMIS, Patient Reported Outcomes Measurement Information System; LLRS-AIM, Limb Lengthening and Reconstruction Society AIM.	

TABLE 2 - Ceiling and Floor Effects of PROMs Instruments Domains and LLRS-AIM Index		
	Ceiling	**Floor**
LD-SRS		
LD-SRS Overall	1 (1.2%)	1 (1.2%)
LD-SRS Pain	17 (21.0%)	1 (1.2%)
LD-SRS Function	1 (1.2%)	1 (1.2%)
LD-SRS Self Image	2 (2.5%)	1 (1.2%)
LD-SRS Mental Health	7 (8.6%)	1 (1.2%)
PROMIS		
PROMIS Anxiety	1 (1.2%)	18 (22.2%)
PROMIS Depression	1 (1.2%)	26 (32.1%)
PROMIS Fatigue	1 (1.2%)	20 (24.7%)
PROMIS Pain Interference	2 (2.5%)	15 (18.5%)
PROMIS Peer Relationship	13 (16.1%)	1 (1.2%)
PROMIS Functional Mobility	19 (23.5%)	1 (1.2%)
LLRS-AIM Index		
LLRS-AIM	1 (1.2%)	19 (23.5%)
LD-SRS indicates Limb Deformity-Scoliosis Research Society; PROMIS, Patient Reported Outcomes Measurement Information System; LLRS-AIM, Limb Lengthening and Reconstruction Society AIM.		

Correction of Femoral Rotational Malalignment with Intramedullary Nailing: A Retrospective Review of PROMs and Complications

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Question: Whether congenital or acquired, femoral rotational malalignment can result in significant functional limitations, pain, and gait abnormalities, even when these alterations may appear subtle. Surgical correction using intramedullary nailing (IMN) offers a biomechanically advantageous and minimally invasive approach that supports early weight–bearing and with reduced complication rates. Despite its growing adoption, there is limited data evaluating the clinical outcomes and safety of IMN specifically for isolated rotational deformity correction. This study aims to assess patient–reported outcomes and complication rates following IMN for femoral rotational malalignment.

Answer: We conducted a retrospective review of patients who underwent acute femoral rotational deformity correction using an intramedullary nail (IMN) between April 2016 and April 2024, with a minimum follow–up of one year. Patients treated with lengthening nails were excluded. Femoral torsion was measured preoperatively using computed tomography (CT) scans. Patient–reported outcome measures (PROMs), including the Limb Deformity–modified Scoliosis Research Society (LD–SRS) questionnaire and the Patient–Reported Outcomes Measurement Information System (PROMIS), were collected both pre– and post–operatively to assess functional improvement. Complications and unplanned reoperations were recorded to evaluate the safety profile of the procedure.

Results: We evaluated 194 femurs from 135 patients who underwent femoral deformity correction with IMN. Of these, 154 femurs had isolated rotational deformities and were included in this analysis. The average patient age was 27 years, with 61.7% identifying as female. The majority of deformities were congenital in origin (136 femurs, 88.3%), while post–traumatic cases accounted for 14 femurs (9.1%). Sixty–two femurs were associated with patients presenting with tetratorsional malalignment.

Patients presented with an average of 35.6° ± 8.7° of femoral anteversion or 7.5° ± 11.5° of retroversion. The mean correction achieved was 20.7° ± 6.1° in cases of anteversion and 21.0° ± 6.3° in retroversion. Across all PROM domains, improvements were observed, with self–image showing statistically significant improvement (LD–SRS score: 2.9 ± 0.8 preoperatively vs. 3.5 ± 0.6 postoperatively, $p = 0.002$).

Regarding complications, seven patients (4.5%) developed infections. Five of these resolved with oral antibiotics alone, while two (1.3%) required surgical irrigation and debridement. Delayed union was observed in five patients (3.2%), all of whom ultimately achieved healing following intervention with either bone marrow aspirate concentrate (BMAC) injection or exchange nailing. Despite large rotational corrections in some patients, very few patients had nerve related symptoms that required intervention (3.2%) and none suffered a permanent injury.

Conclusions: Intramedullary nailing is a safe method for correcting isolated femoral rotational deformities with a low complication rate.

Role of Psychological Resiliency in Predicting Pediatric Limb Lengthening and Reconstruction Outcomes

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Question: Clinical studies have demonstrated that some children and adolescents who undergo limb lengthening and/or reconstruction (LLR) experience a myriad of negative medical and psychological outcomes. What is less well–understood, however, are specific psychological risk factors that, if unaddressed prior to treatment, may predispose a patient to increased medical and psychological complications.

This study sought to address this literature gap by examining the role of psychological resiliency in pediatric LLR. Resiliency is defined by the American Psychological Association as €œthe process and outcome of successfully adapting to difficult or challenging life experiences, especially through mental, emotional, and behavioral flexibility and adjustment to external and internal demands.€ Specifically, the study team sought to evaluate whether preoperative psychological resiliency predicted certain complications experienced by pediatric LLR patients during treatment.

Answer: Chart review was conducted of pediatric patients treated at the Scottish Rite for Children Center for Excellence in Limb Lengthening and Reconstruction (CELLR).

Patients were included in the study sample if they (1) were treated by the CELLR team with either an external fixator and/or intramedullary rod to address a limb length difference and/or deformity diagnosis, (2) were between the ages of 9 and 18 years at the initiation of treatment, and (3) completed preoperative screening questionnaires.

Seventeen patients (ages 11–18) met inclusion criteria. Chart review data was collected, including: patient demographic variables, patient diagnosis and treatment course information, preoperative Resiliency Scales for Children and Adolescents (RSCA) scores, and preoperative Pediatric Symptom Checklist – Youth Report (PSC) scores. Outcome variables included the number of antibiotics prescribed, the number of unplanned outpatient clinic visits, the number of unplanned surgeries, and the number of unplanned readmissions during treatment.

Results: Patient race/ethnicity and sex assigned at birth predicted the number of unplanned clinic visits. In particular, patients who identified as Black / African American were more likely to have unplanned clinic visits, above and beyond the impact of their Resiliency scores. Similarly, patients assigned female at birth were more likely to have unplanned clinic visits, above and beyond the impact of their Resiliency scores.

Sense of Relatedness (an RSCA subscale) and overall resiliency Resources trended toward negatively predicting the number of antibiotics prescribed during treatment. RSCA subscale scores did not predict any other LLR outcomes. PSC scores did not predict any LLR outcomes.

Role of Psychological Resiliency in Predicting Pediatric Limb Lengthening and Reconstruction Outcomes *continued*

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Further, RSCA subscale classifications (e.g., average, at–risk / clinically significant) were not significantly associated with the presence of any LLR outcomes. These latter analyses were very likely limited, however, by the limited number of patients whose self–report RSCA scores fell outside of the normal range.

Conclusions: Based on these results, it seems likely that preoperative psychological and psychosocial functioning plays a role in pediatric patients' ability to cope with LLR. Additional data is clearly needed, however, in order to better understand the specific individual, psychological, and psychosocial factors that impact LLR outcomes, as well as the strength of these relationships.

Comparison of Patient– and Parent–Reported Outcome Measures in Pediatric Limb Deformity Patients as Assessed by the LD–SRS

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Question: The agreement – or lack thereof – between patient– and parent–reported limb deformity Scoliosis Research Society (LD–SRS) questionnaires has not been described. Proxy accuracy varies depending on the patient–reported outcome measure (PROM) used and patient population, with differences reported in zero, some, or all content subgroups. This prospective study compares patient– and parent–reported scores to understand where the LD–SRS falls on this continuum.

Answer: We enrolled 24 children aged 11 to 18 years (mean age 13.8 y, range: 11.0 y to 18.1 y) who had limb deformity surgery (11 internal nail lengthening, 6 osteotomy, 5 guided growth, and 4 external fixation procedures). This cohort consisted of 13 males and 11 females. Children and their guardians completed the appropriate patient– or parent–reported LD–SRS prior to surgery. Using established content subgroups, responses were scored and paired sample t–tests were run on SPSS software to compare patient– and parent–reported means.

Results: A significant difference ($p < 0.05$) was found in the mental health content subgroup (effect size = 0.6), where parents overestimated their child's mental health. No significant differences were observed in the function/activity, pain, or self–image/appearance content subgroups, and global scores did not vary significantly (Table 1).

Conclusions: Although proxy LD–SRS reports are largely informative, the significant difference between patient– and parent–reported scores in the mental health content subgroup emphasizes the value of obtaining PROMs from the adolescent whenever possible.

Table 1. Mean scores and correlations for each category of the LD-SRS (n=24) as reported by the patient or parent. Effect size is only reported for categories with statistically significant differences.

LD-SRS Category	Patient-Report	Parent-Reported	Correlation	p-value	Effect Size
Function/Activity	3.8 ± 0.8	3.8 ± 0.9	0.74	0.51	
Pain	4.2 ± 0.7	4.0 ± 0.8	0.84	0.09	
Self-Image/Appearance	3.6 ± 0.9	3.4 ± 0.8	0.68	0.22	
Mental Health	3.9 ± 1.0	4.2 ± 0.7	0.83	0.03	0.6
Overall	3.8 ± 0.7	3.8 ± 0.7	0.85	0.58	

Impact of Limb Deformity Correction on Pediatric Quality of Life as Assessed by the LD–EOSQ and LD–SRS Patient–Reported Outcome Measures

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Question: The influence of pediatric limb deformity (LD) treatment on a child's quality of life is not well described. A previous study established preliminary validity and reliability of the LD Early Onset Scoliosis Questionnaire (LD–EOSQ) and LD Scoliosis Research Society (LD–SRS) in pediatric LD patients but did not assess patients postoperatively. This multi–center, prospective study assesses changes in these patient–reported outcome measures (PROMs) between preoperative and postoperative scores.

Answer: We enrolled 27 children 18 years and under who had limb deformity surgery (15 guided growth, 12 osteotomy, 5 internal nail lengthening, and 4 external fixation procedures). Children and/or their guardians completed LD–EOSQ (ages 10 and younger, n = 11) or LD–SRS (ages 11 to 18, n = 16) at their initial visit and most recent post–surgical follow–up visits (range 1–5 years). Using established content subgroups, patient responses were scored and paired sample t–tests were run on SPSS software to compare initial and follow–up means.

Results: Significant improvements were observed among the parental (effect size = 0.5, $p = 0.04$) and financial (ES = 1.0, $p = 0.01$) impact content subgroups as measured by the LD–EOSQ (Table 1A). Significant improvements were observed among the function/activity (ES = 0.8, $p = 0.03$) and self–image/appearance (ES = 0.7, $p = 0.04$) content subgroups as measured by the LD–SRS (Table 1B). Global improvements (ES = 0.6, $p = 0.01$) were found in the LD–SRS cohort.

Conclusions: Improved LD–EOSQ and LD–SRS scores suggest that family and patients' quality of life was enhanced by limb deformity correction, which helps validate the use of these instruments in assessing pediatric limb deformity surgery. LD–EOSQ and LD–SRS are promising instruments that may be used in future studies to clarify the efficacy of different surgical treatments in pediatric limb deformity patients.

Table 1. Mean scores for each category of the **A)** LD-EOSQ (n = 11) and **B)** LD-SRS (n = 16) at initial and follow-up timepoints. Effect size is only reported for categories with statistically significant ($p < 0.05$) differences.

A

LD-EOSQ Category	Initial	Follow-Up	p-value	Effect Size
General Health	4.1 ± 0.8	4.1 ± 0.5	0.41	
Pain/Discomfort	3.5 ± 1.2	3.3 ± 0.8	0.20	
Transfer	4.1 ± 1.2	4.2 ± 1.2	0.33	
Daily Living	3.9 ± 1.2	4.2 ± 1.0	0.13	
Fatigue/Energy Level	3.8 ± 1.3	3.8 ± 0.8	0.50	
Emotion	3.7 ± 1.1	3.9 ± 1.3	0.27	
Parental Impact	3.9 ± 0.8	4.2 ± 1.0	0.04	0.5
Financial Impact	3.8 ± 1.2	4.6 ± 0.9	0.01	1.0
Satisfaction	3.6 ± 1.1	3.6 ± 1.2	0.50	
Overall	3.6 ± 0.9	4.0 ± 0.9	0.15	

B

LD-SRS Category	Initial	Follow-Up	p-value	Effect Size
Function/Activity	3.5 ± 0.8	3.9 ± 0.7	0.03	0.8
Pain	4.1 ± 0.6	4.1 ± 0.8	0.32	
Self-Image/Appearance	3.3 ± 0.9	3.7 ± 1.0	0.04	0.7
Mental Health	3.7 ± 1.2	4.0 ± 1.1	0.11	
Overall	3.6 ± 0.7	3.9 ± 0.8	0.01	0.6

Special Guest Lecture

Generative Artificial Intelligence in Orthopedics

Alexander Cherkashin, MD

Session IX:

Limb Lengthening I

David A. Podeszwa, MD, Moderator

The Impact of Multiple Limb Lengthening Procedures: A Single−Center Retrospective Study

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Question: Limb lengthening via distraction osteogenesis is an established treatment for limb length discrepancy and for certain cases of congenital or acquired short stature. While some patients may require multiple procedures on the same limb, the cumulative effect of these repeated lengthenings on bone healing and joint function remains unclear. This study examines how multiple lengthening procedures affect healing time, joint range of motion, and the risk of contractures.

Answer: This single−center, retrospective study included patients who underwent three or more lengthening procedures on the same lower limb, with at least two years of follow−up after the final procedure. Both external fixators and intramedullary limb lengthening nails were included. Data collected included demographics, radiographic measurements, total length gained, time to bone consolidation, healing index, range of motion (pre− and postoperatively), and complications,

Results: Eighteen patients (29 lower limbs) met the inclusion criteria. Of these, 11 underwent bilateral lengthening for achondroplasia. The remaining seven had unilateral lengthenings (three for congenital femoral deficiency, two for Ollier disease, and two for fibular hemimelia). The mean number of lengthenings per patient was 3.08 (range, 3−8). Each procedure gained a mean of 6.85 ± 3.52 cm, with a total lengthening of 20.73 ± 15.25 cm, representing on average 31% ± 22% of the final limb length of 55.42 ± 11.03 cm. Mean time to consolidation was 213.3 ± 109 days, and the overall healing index was 39.2 ± 27.6 days/cm. Multiple linear regression showed that each additional lengthening procedure increased the healing index by 20.43 days ($p<0.001$). Furthermore, for each centimeter of lengthening after two prior procedures, time to recovery of full range of motion increased by 5.5 days ($p<0.05$). Patients who gained more than 60% of their total limb length via distraction osteogenesis were three times more likely to develop contractures exceeding 15° in at least one joint (7% vs. 21%). In terms of complications, three patients required Achilles tendon lengthening for resistant ankle contractures, each having lengthened the tibia by at least 9 cm. Two patients required quadriceps tendon lengthening after gaining more than 26 cm in the femur and tibia combined. No cases of severe or irreversible neurovascular compromise were observed.

Conclusions: Although multiple limb lengthening procedures can be performed safely, the risk of prolonged healing times and joint contractures, particularly after the third lengthening, must be carefully considered. Surgeons and patients should fully discuss the potential risks and benefits when planning repeated lengthening procedures.

Information Transparency for Elective Stature Lengthening Surgery: A Secret–Shopper Study

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Question: Elective stature lengthening (ESL) has gained popularity among individuals seeking to increase their height. Despite its growing appeal, online information about ESL often lacks consistency and transparency. This study evaluates the quality and comprehensiveness of online resources available to prospective patients, focusing on clarity in communication, cost, recovery expectations, and complications.

Answer: Using a secret shopper methodology, we contacted 27 eligible orthopaedic practices globally that offered ESL, posing as a healthy 35–year–old male seeking elective stature lengthening. Practices were contacted via email and follow–up phone calls using a standardized script. Responses were analyzed to evaluate the availability, depth, and variability of information on key topics, including surgery duration, recovery time, cost, insurance coverage, and complications.

Results: Contact was successfully established with 17 (63%) of practices. However, only 3/27 (11%) of the contacted practices answered all scripted questions. Cost estimates varied substantially, ranging from $15,000 to $150,118 (mean = $77,133, SD = $35,603.58). Anticipated recovery time was similarly variable, ranging from 2 to 365 days (mean = 202 days, SD = 137.27). Crucial details, such as patient eligibility and potential complications, were frequently omitted.

Conclusions: The study highlights a critical need for improved transparency and standardization in online resources for elective stature lengthening. Addressing these gaps could enhance patient trust, satisfaction, and informed decision–making, underscoring the importance of establishing guidelines for consistent communication in this emerging field.

Is It Safe to Drive During Femoral Limb Lengthening? A Prospective Study of Brake Reaction Performance

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Question: Driving safety is of particular concern when the operative limb is responsible for pedal control. This prospective, single−center study investigates whether right−sided femoral intramedullary limb lengthening (MILN) influences brake reaction time or brake reaction force during the lengthening process.

Answer: Eight male patients (mean age 32 ± 9 years) undergoing right−sided femoral MILN were enrolled. Eligible participants drove daily prior to surgery and had no more than 5° of knee flexion deficit. Patients requiring concurrent tibial lengthening or external fixation were excluded. Brake reaction time (milliseconds) and brake reaction force (N/m^2) were measured via an in−shoe sensor at four time points: preoperatively, within three weeks postoperatively, midway through lengthening, and at the end of lengthening. Statistical analysis was performed using repeated−measures testing, with $p<0.05$ considered significant.

Results: Mean brake reaction time was 607 ms preoperatively, 595 ms at three weeks postoperatively, 598 ms midway through lengthening, and 577 ms at the end of lengthening. Mean brake reaction force was 431 N/m^2 preoperatively, 410 N/m^2 at three weeks postoperatively, 405 N/m^2 midway through lengthening, and 451 N/m^2 at the end of lengthening. All differences compared to baseline were nonsignificant ($p>0.05$)."

Conclusions: In this cohort of patients undergoing right−sided femoral MILN, there were no clinically or statistically significant changes in brake reaction time or force from before surgery through the end of lengthening. These preliminary findings indicate that, under appropriate rehabilitation protocols and with careful patient selection, many individuals may be able to safely resume driving during the femoral lengthening process.

Humeral Lengthening in Patients with Achondroplasia: Clinical Results and Complications of Intramedullary Nailing and External Fixation

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Question: What are the clinical results and complications of primary humeral lengthening in patients with achondroplasia?

Answer: A retrospective chart review was performed on patients with achondroplasia who underwent humeral lengthening between August 2017 and June 2024. Second lengthenings were excluded. Surgical technique (intramedullary nail (IMN) vs. external fixator (ex–fix)), length achieved (cm), and pre– and post–operative elbow range of motion (ROM) measurements were recorded. Complications and reoperations were also collected. A Mann–Whitney U test compared length achieved between implant groups. Chi–square tests analyzed comparisons between implant types and complications. ROM measurements were analyzed using independent t–tests. Patients with concomitant distal humeral/proximal ulnar osteotomies were excluded from comparisons of pre– and post–op ROM measurements. A p–value <0.05 was considered significant.

Results: Thirty–four patients (14 males/20 females) with a median age of 14.2 years (range 9.4 €“ 28.2 years) were included. All patients underwent bilateral humeral lengthening. Four patients had concurrent distal humerus correction for flexion deformity and 5 patients had proximal ulnar correction. Eight patients underwent IMN (23.5%) and 26 patients (76.5%) had external fixator lengthening. The mean preoperative humeral length in the ex–fix and IMN groups was 16.3 cm (±2.2 cm) and 21.3 cm (±3.6 cm), respectively ($p < 0.001$, Hedges€™ $g = 1.97$, large effect). All patients who underwent IMN lengthening achieved 5 cm of length, while the external fixator group achieved a median of 10 cm (range 5.0 – 12.5 cm) ($p=0.0007$, effect size = 0.81, large effect). The mean pre– and post–op elbow ROM for the cohort was 109.3° (±22.7°) and 113.9° (±22.2°), respectively, with no significant difference between implant groups ($p = 0.2483$). The mean pre– and post–op flexion deformity was 17.4° (±18.2°) and 9.6° (±19.0°), respectively, with no significant difference between groups ($p = 0.5601$). There was no difference between pre– and post–op flexion deformity ($p = 0.3319$) and elbow ROM ($p = 0.5436$). Complications included 8 radial nerve palsies (5 requiring surgical decompression), 1 transient ulnar nerve palsy, 2 humeral shaft fractures, and 3 elbow contractures (all requiring repeat operations). One patient had recurrent infections of a distal humerus pin that required reoperation (prior to ex–fix removal) for pin removal and debridement. There was no significant difference in complication rates between IMN and ex–fix groups ($p = 0.7389$). A strong association ($p < 0.0001$) was found between right and left side complications, indicating symmetry (e.g., no complication on the right side suggests no complication on the left).

Conclusions: Primary humeral lengthening in patients with achondroplasia is a reliable procedure for increasing arm length while preserving elbow range of motion. External fixation allows for substantially greater lengthening, likely due to inherent implant limitations in IMN. Both IMN and ex–fix have similar complication profiles and most were manageable and did not result in long–term functional loss. These findings support the consistency of humeral lengthening and the continued use of both techniques, with the choice of implant guided by desired length gain and patient–specific considerations.

General Population Perceptions on Stature Lengthening

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Question: This study sought to evaluate the general population's perception of cosmetic stature lengthening and to determine what factors influence these perceptions.

Answer: A prospective cohort study was performed utilizing a 40–question survey distributed via a validated, public, online marketplace in March 2024. After collecting baseline demographics, participants were queried on previous experience with cosmetic surgery, ethical opinions on cosmetic surgery, ethical opinions on stature lengthening and personal interest in stature lengthening surgery.

Results: There were 496 participants, 273(55%) males and 217(44%) females with an average age of 43.7(21–78) years. When asked how they would evaluate their own height, 95(19%) self–identified as short, 282(57%) average, 119(24%) tall. 63% of participants believed that stature lengthening is ethically acceptable, and 70% thought cosmetic stature lengthening is ethically equivalent to conventional cosmetic surgery. 7% of participants stated that they would personally consider getting cosmetic stature lengthening. Those that were open to conventional cosmetic surgical procedures were more likely to consider cosmetic stature lengthening ($P<0.01$), regardless of if expenses were out of pocket ($P=0.03$) or covered by insurance ($P<0.01$). Regression analysis demonstrated no correlation for willingness to undergo limb lengthening and subjective beliefs about personal height. However, when this same analysis was assessed based upon their objective, numerical height, shorter people were more willing to get cosmetic limb lengthening.

Conclusions: The primary findings of this study were that a majority of the population believes cosmetic stature lengthening is ethically acceptable, while only 7% of the population would personally consider undergoing cosmetic stature lengthening. Objective participant height was found to be significantly related to interest in undergoing cosmetic stature lengthening. While these findings provide unique insights into the general populations' perceptions of stature lengthening, further studies should focus on identifying factors contributing to the opposition against stature lengthening. It is important to further elucidate the prospective patient's understanding of the significant commitment required to have a successful stature lengthening experience.

Presidential Guest Speaker

Ilizarov Method of Surgical Manipulation with Bone Length, Shape, and Structure

Mikhail Samchukov, MD

Dr. Samchukov is a worldwide expert on distraction osteogenesis and external fixation techniques who has been on staff at Texas Scottish Rite Hospital for Children since completing his Visiting Professorship program in 1991. He received his medical degree at Khabarovsk Medical Institute in Russia and had a very successful career of orthopedic surgeon and scientist in his home country working as a Deputy General Director of the Ilizarov Orthopedic Research Center, Kurgan, Russia. Currently, Dr. Samchukov is the Co-Director of the Center for Excellence in Limb Lengthening and Reconstruction in the Seay Research Center at Texas Scottish Rite Hospital for Children, Dallas, Texas. He also serves as an Associate Professor in the department of orthopedic surgery at the University of Texas Southwestern Medical Center, Dallas and associate professor in the department of biomedical sciences at Texas A&M University System Health Science Center in Dallas.

For many years, Dr. Samchukov's primary research interest and initiatives included limb lengthening, deformity correction, and bone transport; computer assisted preoperative planning and monitoring; distraction osteogenesis and histiogenesis; and external skeletal fixation. His contribution to the field of distraction osteogenesis and external skeletal fixation is hard to overestimate. He is a co-developer of the TrueLok, TL-Trauma, TL-Hex, TL-EVO, and TL-Elevate external fixation systems and holds 135 patents. He was a chief editor on 5 books and manuals and is widely published in the area of distraction osteogenesis and external skeletal fixation. His list of publications includes 52 book chapters, 92 peer review articles, and 327 abstracts. Because of his unique knowledge and tremendous experience, Dr. Samchukov has received numerous research grants and is regularly invited as a guest speaker to national and International symposiums.

Session X:

Osseointegration I

Lee Zuckerman, MD, Moderator

Primary Amputation with Osseointegration Versus Osseointegration for Existing Amputation

S. Robert Rozbruch, MD; Mohamed Abdelaziz Elghazy,MD; Zachary Glassband, BA; Taylor J. Reif, MD; Jason S. Hoellwarth, MD
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Question: Osseointegration (OI) for lower limb amputees confers improvement of patient quality of life, prosthetic use, and walking ability by eliminating socket related problems. However, the available literature has no studies focusing on the suitability for primary amputation with osseointegration, versus the more commonly performed osseointegration for existing amputees. The aim of this study was to compare the clinical and surveyed outcomes of these two patient types.

Answer: Patients who had lower extremity osseointegration with a minimum of one year follow up at a single institution were reviewed. They were categorized into two groups. Group 1 were patients who had primary amputation with simultaneous osseointegration in a single surgery. Group 2 were patients who had osseointegration for an existing amputation. Patients who had primary amputation as a direct setup for near–term planned osseointegration performed at a separate surgery were excluded. Adverse events were recorded, and change of mobility and LD–SRS and PROMIS outcome scores were compared.

Results: There were 139 limb segments, 81 femurs and 58 tibias. 15 patients had simultaneous amputation and OI (4 femoral and 11 tibial), while 124 patients had OI for a well–established amputation (64 femur and 32 tibia). There were no statistically significant differences in the rate of any adverse event category. The data for 81 femurs is presented as simultaneous (4/81=5%) vs existing (77/81=95%). Surgical debridement was 2/4=50% vs 12/77=16%, p=.139. Periprosthetic fracture was 1/4=25% vs 9/77=12%, p.420. Skin refashioning was 2/4=50% vs 10/77=13%, p=.105. Removal for infection was ¼=25% vs 1/77=1%, p=.098. The data for 58 femurs is presented as simultaneous (11/58=19%) vs existing (47/58=81%). Surgical debridement was 2/11=18% vs 1/47=2%, p=.089. No periprosthetic fractures occurred. Skin refashioning was 0 vs 1/47=2%, p=1.000. Non–infectious loosening, removal for infection, and removal for implant fracture were all 0 vs 1/47=2%, p=1.000. All mobility outcomes and LD–SRS and PROMIS survey domains significantly improved for both the simultaneous and existing cohorts. The magnitude of improvements were similar between the two cohorts.

Conclusions: Patients who have simultaneous amputation with osseointegration versus osseointegration for an existing amputation have similar improvement of mobility and surveyed outcomes, without a recognizable difference in adverse event rate. It seems reasonable to perform osseointegration at the time of primary amputation for well–informed patients who do prefer to rehabilitate with osseointegration rather than a socket prosthesis.

Transcutaneous Osseointegration for Adults Whose Amputations were Performed During Childhood

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Question: Osseointegration limb replacement has consistently demonstrated improved mobility, balance, and proprioception for amputees, eliminating common socket prosthesis problems including skin irritation, poor fit, and pain. Patients whose amputations were performed as children can have additional considerations versus adulthood amputations, but have never been specifically evaluated vis−a−vis osseointegration. This research describes the outcomes and considerations of osseointegration for patients whose index amputation was during childhood.

Answer: Retrospective review was performed of all our osseointegration patients who had index amputation as children. The primary outcome was postoperative adverse events. Additionally, specific childhood amputation considerations were identified (such as management of overgrowth bone).

Results: Thirteen osseointegration procedures in 12 patients were included. All patients had revision of a prior amputation performed during childhood. Indications for osseointegration were: socket fit (10), skin problems (11), pain (9), and mobility (7). Three patients had adverse events. One patient had surgical debridement with implant retention. One patient fractured his implant due to a horse−related accident, prompting implant removal with subsequent revision osseointegration. One patient had a periprosthetic femur fracture managed with non−weight bearing and has regained full mobility. Two patients had spike overgrowths, two patients had amputations through a joint, one had an Ertl, and one had heterotopic ossification. While these anatomic considerations required attentive preoperative planning, none led to intraoperative difficulty or apparent postoperative issues.

Conclusions: Osseointegration can be performed safely and successfully for adults whose amputations were performed during childhood. Patients with anatomic considerations such as spike overgrowth require specific preoperative planning but seem unlikely to have notable intraoperative or postoperative difficulties. The adverse events that do occur are typical of osseointegration patients in general and are managed with established strategies.

Press–fit Osseointegration for Patients with Short Residual Bone

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Question: Press–fit titanium transcutaneous osseointegration nails (TiTON) have been proven reliable in improving amputee quality of life and mobility. However, the minimum necessary length of bone or the minimum implant length to achieve stable TiTON is not established. The aim of this study was to compare the adverse event experience of patients with short residual limbs versus patients with longer residual limbs. 8 cm was chosen as the definition of €œshort€ because the standard length for traditional models is 8 cm, and the fully textured portion for standard current models is 8 cm long.

Answer: Medical records were evaluated of femur and tibial osseointegration patients. Patients were excluded if they had less than one year follow up or if they had osseointegration with an implant design other than TiTON. Both femoral and tibial patient cohorts were separated into Short (8 cm) cohorts based on implant length. Chart review included demographics and whether additional surgery occurred to manage infection, noninfected loosening, periprosthetic fracture, and skin refashioning.

Results: 144 limbs were evaluated. There were no statistically significant differences in the rate of any adverse event category. The data for 81 femurs is presented as short vs long, 8 (10%) vs 74 (91%); the shortest was 40 mm. Debridement was performed for 1/8=12.5% vs 12/73=16%, p=1.000. Periprosthetic fractures occurred for 2/8=25% vs 7/73=9%, p=.211; all regained ambulation with implant retention. Skin refashioning was performed for 0 vs 13/73=18%, p=.344. Implant removal for infection was performed for 0 vs 2/73=3%, p=1.000. The data for 63 tibias is presented as short vs long, 16 (25%) vs 46 (73%), the shortest was 45 mm. Debridement was performed for 0 vs 3/46=7%, p=.562. Implant removal for non–infectious loosening was 1/16=6% vs 1/46=2%, p=.453. Skin refashioning was performed for 1/16=6% vs 0, p=.258. Removal for infection was 0 vs 1/46=2%, p=.453. Implant removal for implant fracture was 0 vs 1/46=2%, p=.453).

Conclusions: While this study is limited by the total number of short implants, the current data suggests that short TiTON implants do not have an apparent risk for adverse events versus longer implants. This is remarkably notable for concerns such as loosening and removal. Larger numbers of patients are needed to more confidently assess potential limitations of short implants, but currently, patients with residual bones as short as 4 cm seem safe to provide TiTON rehabilitation.

	Total	Short TiTON: <=8 cm	Long TiTON >8 cm	P*
FEMUR				
Irrigation and debridement	13 (15.9%)	1 (12.5%)	12 (16.2%)	1
Fracture	9 (11%)	2 (25%)	7 (9.5%)	0.2114
Skin Refashioning	13 (15.9%)	0 (0%)	13 (17.6%)	0.5822
Noninfected loosening	0 (0%)	0 (0%)	0 (0%)	1
Infection Requiring Removal	2 (2.4%)	0 (0%)	2 (2.7%)	1
Trauma Requiring Removal	1 (1.2%)	0 (0%)	1 (1.4%)	1
TIBIA				
Irrigation and debridement	3 (4.8%)	0 (0%)	3 (6.4%)	0.5645
Fracture	0 (0%)	0 (0%)	0 (0%)	1
Skin Refashioning	1 (1.6%)	1 (6.3%)	0 (0%)	0.254
Noninfected loosening	2 (3.2%)	1 (6.3%)	1 (2.1%)	0.4465
Infection Requiring Removal	1 (1.6%)	0 (0%)	1 (2.1%)	1
Trauma Requiring Removal	1 (1.6%)	0 (0%)	1 (2.1%)	1

Table 1: The difference in reoperation causes between short and long TiTON in both femur and tibia cohorts.

Medium–term Outcomes of Transtibial Osseointegration in Association with Total Knee Replacement

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Question: Transtibial osseointegration (TFOI) for amputees has limited but clear literature identifying superior quality of life and mobility versus a socketed prosthesis. Some amputees have knee arthritis that would be relieved by a total knee replacement (TKR). No other group has reported performing a TKR in association with TTOI (TKR+TTOI). We report the outcomes of nine patients who had TKR+TTOI, followed for an average 6.5 years. Study aimed to analyse the following: 1) what is the rate of complication following primary procedure; 2) how does patient prosthesis wear time and mobility change; 3) how does the patient's perception of using a prosthesis change (based on the Questionnaire for Persons with a Transfemoral Amputation, QTFA)?

Answer: Our osseointegration registry was retrospectively reviewed to identify all patients who had TTOI and who also had TKR, performed at least two years prior. Four patients had TKR first the TTOI, four patients had simultaneous TKR+TTOI, and one patient had 1 OI first then TKR. All constructs were in continuity from hinged TKR to the prosthetic limb. Outcomes were: complications prompting surgical intervention, and changes in daily prosthesis wear hours, Questionnaire for Persons with a Transfemoral Amputation (QTFA), and Short Form 36 (SF36). All patients had clinical follow–up, but two patients did not have complete survey and mobility tests at both time periods.

Results: Six (67%) were male, average age 51.2±14.7 years. All primary amputations were performed to manage traumatic injury or its sequelae. No patients died. Five patients (56%) developed infection leading to eventual transfemoral amputation 36.0±15.3 months later, and 1 patient had a single debridement six years after TTOI with no additional surgery in the subsequent two years. All patients who had transfemoral amputation elected for and received transfemoral osseointegration, and no infections occurred, although one patient sustained a periprosthetic fracture which was managed with internal fixation and implant retention and walks independently. The proportion of patients who wore their prosthesis at least 8 hours daily was 5/9=56%, versus 7/9=78% (p=.620). Even after proximal level amputation, the QTFA scores improved versus prior to TKR+TTOI, although not significantly: Global (45.2±20.3 vs 66.7±27.6, p=.179), Problem (39.8±19.8 vs 21.5±16.8, p=.205), Mobility (54.8±28.1 vs 67.7±25.0, p=.356). SF36 changes were also non–significant: Mental (58.6±7.0 vs 46.1±11.0, p=.068), Physical (34.3±6.1 vs 35.2±13.7, p=.904).

Conclusions: TKR+TTOI presents a high risk for eventual infection prompting subsequent transfemoral amputation. Although none of these patients died, in general, TKR infection can lead to patient mortality. Given the exceptional benefit to preserving the knee joint to preserve amputee mobility and quality of life, it would be devastating to flatly force transtibial amputees with severe degenerative knee joint pain and unable to use a socket prosthesis to choose between TTOI but a painful knee, or preemptive transfemoral amputation for transfemoral osseointegration. Therefore, TTOI for patients

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who also request TKR must be considered cautiously. Given that this frequency of infection does not occur in patients who have total hip replacement in association with transfemoral osseointegration, the underlying issue may not be that linked joint replacement with osseointegrated limb replacement is incompatible, but may require further consideration of biological barriers to ascending infection and/or significant changes to implant design, surgical technique, or other yet–uncertain factors.

Session XI:

Limb Lengthening II

Harold J.P. van Bosse, MD, Moderator

Outcomes Following Sequential Internal Lengthening of Long Bones: A Case Series

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Question: With internal bone lengthening nails being utilized extensively over the past ten years for patients with limb length discrepancies, some patients have now had the opportunity to undergo multiple lengthening procedures using this technique. We are not aware of any study evaluating sequential internal bone lengthenings. Our objective was to review treatment outcomes in patients who underwent more than one internal lengthening procedure in the same long bone.

Answer: We present a retrospective review of a series of seven patients who underwent two consecutive internal lengthening procedures on the same femur. This series included four patients with congenital femoral deficiency, one patient with fibula hemimelia, and two patients with physeal growth arrest (one traumatic and one post−infective). We documented patient demographics at the time of surgery and compared the bone healing index (BHI) at both surgeries.

Results: There were four male and three female patients with a mean age at the time of first surgery of 9.9 ± 5.1 years. The left femur was involved in 5 cases. The median (and Interquartile range, IQR) duration between the two surgeries was 46 (25) months. There was no significant difference in the amount of length discrepancy before the first and second lengthening procedures or the amount of length gained ($p = 0.9062$ and 0.6250, respectively). We also found no significant difference between the median bone healing index for the first and second lengthening procedures ($p = 0.2969$). We did, however, note that the duration of regenerate bone maturation appeared to be less predictable after the second surgery, as represented by a wider range of the bone healing index (12.5 vs. 42.8 days/cm). (See Figure and Table below)

Conclusions: Sequential lengthening of the same bone with an internal lengthening nail appears to heal comparably in both lengthening sessions as evidenced by the fact that we did not find the median bone healing index (BHI) between either lengthening surgery to be significantly different. We did find that the duration of healing following the second bone lengthening procedure appeared to be less predictable than the first indicating that there may be some mild, subclinical effect of the previous lengthening on the second lengthening using an internal lengthening nail.

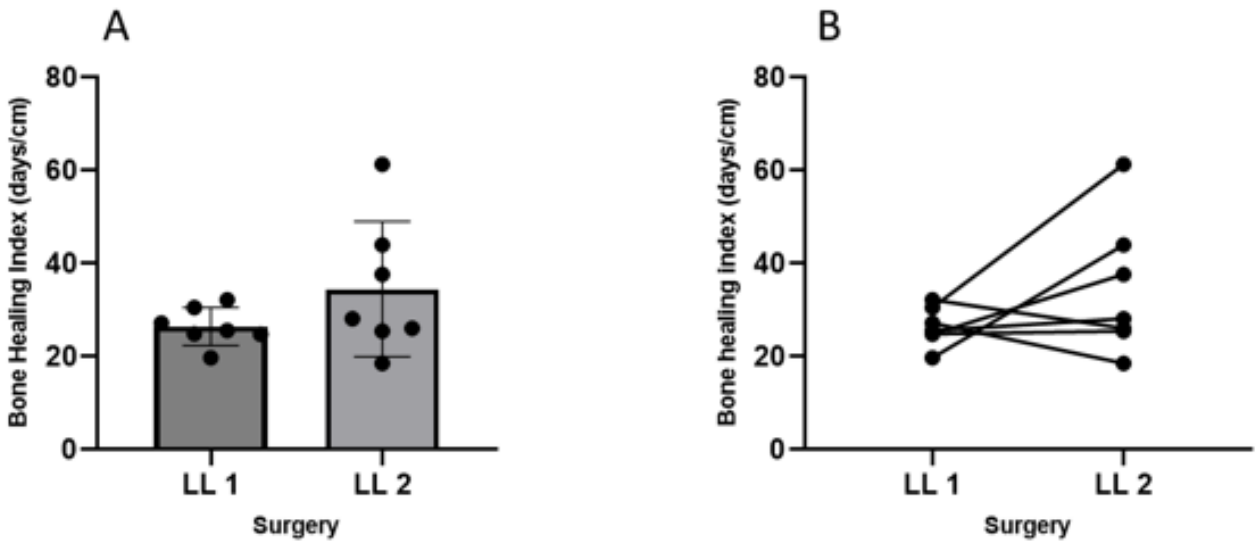

Figure. Comparison of bone healing index following sequential internal limb lengthening (LL 1 – first lengthening procedure, LL 2 – second lengthening procedure). **A**. Histogram showing comparison of the mean BHI for both lengthening procedures. **B**. Line graph showing the direction of change in BHI between the two lengthening procedures for each patient.

Table. Summary of patient demographics and results of the internal bone lengthening procedure. S1 = first surgery; S2 = Second surgery

s/n	Age	LLD at S1	Length gain (cm) at S1	BHI for S1	Duration (months) between S1 and S2	LLD at S2	Length gain (cm) at S2	BHI for S2	Follow-up duration (months)
1	17	5	3.5	30.57	24	3	2.2	61.36	21
2	6	9	3.1	32.26	49	11	4.9	26.12	9
3	9	4	3.2	25.63	54	5.5	4.9	28.16	12
4	17	13	5	24.80	15	8	4.4	37.72	10
5	5	7	4.5	19.78	44	7.5	3.7	44.05	5
6	6	3	4	27.25	46	4	4.8	18.54	16
7	9	6	4.5	24.89	47	5	4.7	25.53	42

Complication Rates in Cosmetic Bilateral Femoral Lengthening Using Intramedullary Lengthening Nails

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Question: Motorized intramedullary lengthening nails (MILNs) have expanded limb−lengthening procedures beyond deformity correction to include cosmetic height gain. However, concerns remain regarding complication rates and patient selection. This study evaluated functional outcomes, height gain, treatment duration, and complications in a single−surgeon, large−cohort series of patients undergoing bilateral cosmetic limb lengthening with MILNs.

Answer: A retrospective review included 78 patients (156 nails), comprising 68 femoral and 10 tibial lengthening cases, all with height dysphoria and at least two years of follow−up. Data collected included demographic characteristics, pre− and postoperative height, nail dimensions, distraction rate, consolidation times, and complications classified by modified Clavien−Dindo and Cherkashin systems. Logistic regression was used to identify predictors of complications, with significance set at $p<0.05$.

Results: The mean age was 31.6 years (range, 17−48). Femoral lengthening achieved a mean gain of 7.3 cm (167 ± 6.1 cm to 174 ± 5.7 cm) at a distraction rate of 0.8 mm/day, requiring roughly 300 days to reach consolidation. Tibial lengthening ($n = 10$) yielded an average 7 cm gain at 0.6 mm/day ($p<0.05$), with consolidation in approximately 347 days. Overall, 72% (49/68) of femoral and 20% (2/10) of tibial patients experienced complications, most managed conservatively. Contractures were most common, followed by hardware failure and delayed union. Age was a significant predictor of complications (odds ratio = 1.07 per year; $p = 0.0445$).

Conclusions: Although complications were frequent, the majority resolved without additional surgery. Careful patient selection, vigilant follow−up, and strict physical therapy protocols can reduce morbidity. MILNs offer a safe and effective option for patients seeking cosmetic stature enhancement.

A Comparison of Automated and Manual Strut Adjustment Systems for Circular Frame Correction of Limb Deformity in Pediatric and Adolescent Patients

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Question: What are the quantitative and qualitative differences between automatic strut and manual strut adjustment systems in treating limb lengthening and deformity correction in pediatric and adolescent patients?

Answer: A retrospective chart review of 35 patients undergoing correction for limb deformity (24 [redacted] 11 manual strut adjustment systems) was conducted at an urban, tertiary children's hospital. Demographic information, surgical information, complications, and patient outcome data including quantitative bone regenerate calculations (Pixel Value Ratio (PVR)) were compared between the "automated" and "manual" strut adjustment groups. Statistical significance was determined by p−values from Fisher's exact test for categorical variables and from a two−sample t−test assuming unequal variances for continuous variables. Additional qualitative observations were recorded.

Results: Out of 35 patients, 24 patients (68.6%) were treated using the [redacted] automatic strut adjustment system, and 11 patients (31.4%) were treated in a mixed cohort of manual strut adjustment systems. The average age was 13.3±3.6 years (ranging 4−19 years) for the automated strut adjustment group and 13.6±2.4 years (ranging 10−17 years) for the manual strut adjustment group, with the majority being male (automated: 83.3%; manual: 81.8%). The mean BMI ranged from 32.5±11.9 kg/m2 in the automated strut adjustment group to 30.5±10.6 kg/m2 in the manual strut adjustment group. All patients were definitively treated for deformity correction in the tibia/fibula. One patient (4.2%) in the automated strut adjustment group was also treated after failed hemiepiphysiodesis and one patient (9.1%) in the manual strut adjustment group was also treated for a fracture reduction. In the automated strut adjustment group, 19 patients (79.2%) had Blount's disease, as well as 8 patients (72.7%) in the manual strut adjustment group. Among the automated strut adjustment group, two patients had metaphyseal chondrodysplasia of Schmid type, one patient had a history of asthma and bilateral tibial tuberosity fracture, one patient had Charcot−Marie−Tooth (CMT) type 4c, and one patient had multiple hereditary exostoses. In the manual strut adjustment group, three patients each had distinct comorbidities, including multiple hereditary exostoses, asthma, and diabetes. The total surgical times were similar between the two groups, with an average duration of 231.1±40.1 min in the automated and 227.2±37.4 min in the manual strut adjustment group. A statistically significant difference between the automated and manual strut adjustment groups was identified concerning the postoperative variable of total lengthening (mm) and the duration of external fixation (weeks). The automatic strut adjustment group demonstrated a mean total lengthening of 11.7±8.4 mm, in contrast to the manual group, which exhibited a mean lengthening of 6.4±4.5 mm (P=0.024). Total lengthening in two patients treated with [redacted] could not be assessed due to the device obstructing the osteotomy site. The mean (SD) duration of external fixation was 12.0±3.4 weeks in the automated and 15.4±4.1 weeks in the manual strut adjustment group (P=0.0264). The duration of external fixation was highly correlated with the mean change in strut position (P= 0.0234). Frame−on time vs. mean strut difference was also compared between the two groups as a measure of device utilization for deformity correction. Using a 2 variable regression model, p−values were p=0.0493 for the manual group and p=0.0058 for the automated group. One patient in the automated strut adjustment group demonstrated healing at 16 weeks but a frame−on−time of 31 weeks due to social issues and was censored from the analysis regarding the duration of external fixation.

A Comparison of Automated and Manual Strut Adjustment Systems for Circular Frame Correction of Limb Deformity in Pediatric and Adolescent Patients *continued*

David Cieremans, DO, MS; Michael Luedtke, MS; Sarah Bosshard, PhD; James Lesko, PhD; Sarah Contrucci, DO; Mohammad Darsalim, BA; Kimberly Nocella, MSN, RN David Diaz, PhD; Alex Wu, MD, PhD; Joseph Rosenblatt, DO
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Although not statistically significant (P=0.108), the Anterior/Posterior Pixel Value Ratio (PVR) was 1.03±0.10 in the automatic strut adjustment group (n=20) compared to 0.95±0.11 for the manual strut adjustment group (n=9). The PVR is a quantitative image analysis measurement for bone regeneration. A ratio closer to 1 indicates regenerate bone that is like the anterior or posterior bone intensity values. Both Anterior/Posterior and Lateral PVR were greater than 0.8 for all but one subject at the time of external fixator removal. There was nearly no correlation between Anterior/Posterior and Lateral PVR (P=0.150). In total, 6 patients' radiographs were unable to be assessed due to visual obstruction of the frame and therefore the patient's information was censored from the Anterior/Posterior PVR analysis. No statistically significant differences between the two groups were observed for other postoperative outcomes, such as lengthening index (LI) which serves as a general indicator to analyze bone healing. The same was true for number of strut swaps (0 swaps in 66.7% vs 81.8%), mean (SD) number of follow−up visits (6.8±1.8 vs. 5.5±2.4), mean (SD) number of X−rays until frame removal (5.2±1.4 vs. 5.0±1.7), mean RUST score (11.3±1.8 vs 10.9±1.3), and the percentage of subjects with consistent pan throughout treatment (33.3% vs. 27.3%). Each group reported 3 pin−site infections (automated: 12.5%, manual: 27.3%); however, the manual group exhibited more severe infections classified using the wire and pin site classification and treatment described in Dahl et al. 1994. No fracture related infections were observed. Union was achieved for 23 (95.8%) patients in the automated compared to 10 (90.9%) in the manual group. Two patients (one in each group) did not achieve union post−index surgery before frame removal. Both ultimately received an intramedullary nail to achieve deformity correction and definitive fixation. One patient (4.2%) in the automated group developed an aseptic union,but then proceeded to develop callus and interval healing. Qualitative differences were based upon investigator interactions with the caregivers. Post−operative encounters suggest greater ease of use and compliance in the automated system from a provider perspective.

Conclusions: Analysis of our patient population indicated a statistically significant difference in mean limb lengthening (11.7 vs 6.4mm) and in mean duration of external fixation (12.0 vs 15.4 weeks) between automated and manual strut adjustment groups. Regression analysis of frame−on time vs. mean strut difference suggests that automated and manual devices had similar frame−on time, but it took less time for the automated device to accomplish this. This was not the initial intention of the automated device and basic lengthening principles of >1mm/day were not violated. The Anterior/Posterior PVR for the automated group indicated a trend in improved bone regenerate quality as compared to patients with manual strut adjustments (1.03±0.10 vs 0.95±0.11). Demographic characteristics and surgical variables were evenly distributed in our cohort with no statistical differences observed between the automated strut adjustment and manual strut adjustment groups. Our results suggest an improvement to the standard of care in this patient population. One limitation is the relatively small sample size of the two study groups. Second, the study population consisted primarily of pediatric patients and did not include adults. Third, we did not administer a validated questionnaire to assess patient and caregiver satisfaction due to the retrospective nature of the study. As a result, we were only able to report ease of use from a provider perspective. Future follow−up studies with a larger sample size are needed to verify the significance of our results and to assess patient−reported outcomes between the two treatment modalities.

Gradual Distalization of Chronic High Dislocation of the Hip with Motorized Nail Before Arthroplasty in Anatomical Position – A Case Series

Mathias Mosfeldt, MD; Henrik Lundblad
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Question: Is treatment of chronic high dislocation of the hip by gradual distraction of the soft tissue over several weeks with a fully implantable motorized nail prior to arthoplasty a safe and viable option? The technique was first proposed by Baumgart et al. in 2005 (Reduction of high dislocation of the hip using a distraction nail before arthroplasty. J Bone Joint Surg Br 87:565–567), and we applied a slightly modified version of this method similar to the one published by Baumgart et al. in 2023 (Reduction of High Hip Dislocation with a Distraction Nail and Arthroplasty).

Answer: We present our experiences and findings of using this technique in four separate cases between 2021 and 2024. All four cases were adults, ages 19–66, with chronic high dislocation of the hip and unmanageable symptoms. Surgery was done in a two–stage procedure. Gradual distraction of the soft tissues was initiated after the first surgery with a fully implantable motorized nail that a custom head cap and articulated with a custom–made temporary cup fixed to the pelvis. Distalization was done over the course of 6–8 weeks and the second procedure with extraction of the lengthening nail and temporary cup as well as the total hip arthroplasty was done 8–10 weeks after the initial procedure. For the earliest patients in our series we have several years of follow–up.

Results: All patients treated obtained a good position of the hip arthroplasty considering the challenging preoperative situation. The period between procedures was somewhat problematic due to the restrictions in range of motion of the hip and weight–bearing. Furthermore, two of the patients suffered symptoms of overstretching the sciatic nerve, one of which had not resolved at the time of writing, despite both being asymptomatic in this regard during the period of distalization before the arthroplasty. All patients had significantly improved gait and have well functioning hip prosthesis.

Conclusions: The method seems very promising but despite gradual distraction we encountered problems with regards to overstretching of the ischial nerve, Moving forward, this type of complication might be mitigated with modifications to the procedure, peri– operative protocol and patient selection.

Deborah F. Stanitski, MD
LLRS Diversity Presentation

A Culture in LLRS Where Everyone can Thrive and Develop

Marie Fridberg, MD, PhD

Deborah F. Stanitski, MD

Dr. Debbie Stanitski is a retired pediatric orthopedic surgeon and former event rider who sustained a traumatic brain injury in 1999. Today she competes in Para Dressage with her Danish mare Skovlunds de Nice ("Jolie"). Debbie lives in Charleston, South Carolina with her husband Carl.

- Born Chicago, Illinois June 12,1953. One brother November 2,1954
- AFS student in Penang. Malaysia 1970
- BA Smith College 1975-microbiology and Asian Studies. Sigma Xi honor society
- Rockefeller University-tumor virology 1975-6
- 1976-80 M.D. University of Cincinnati
- 1981-1985 Harvard University resident in orthopedic surgery
- January-July 1986trauma fellowship University of Toronto
- July-December 1986 Pediatric Orthopedic fellowship University of Toronto
- 1986-91 Lecturer and Assistant Professor University of Toronto
- 1991-October 1998. Associate Professor and assistant department chief Children's Hospital of Michigan
- October, 1998- December 2005 Full Professor Medical University of South Carolina, Charleston
- March 14, 1999 closed head injury. January, 2000- retirement in December, 2005 nonoperative orthopedics
- Currently need walker for balance; wheelchair for long distance.
- Currently spend much time playing croquet (have advanced to tournament level from beginner). 4-5 x/week
- Paraequestrian dressage on newish (June, 2024) 6 year old calm bay gelding- 4-5x/week
- Gym 6x/week

Dr. Deborah Stanitski: Life After a Traumatic Brain Injury

Marie Fridberg, MD, PhD

- Paediatric orthopaedic surgeon from Denmark
- LLRS Paediatric travelling fellow of 2023 and IPOS-POSNA scholarship recipient 2018
- In 2025 with excellence awarded the PhD degree for the thesis entitled “Postoperative infection monitoring using thermography” which including a clinical study on more than 2000 pin-sites
- Since 2022 Board member of the International Orthopaedic Diversity Alliance as European representative
- Previous Board member of the Danish Orthopaedic Society (2015-2021) as the first female ever
- Founder of the Danish Female Society and among the founding board members of the Danish Trainee Association
- Also been holding roles on the European Federation of Orthopaedics and Traumatology (EFFORT) and the Nordic Orthopaedic Federation (NOF) boards
- Recipient of the Edward E Walstar Award from the European Orthopaedic Research Society (EORS) in 2024 for overall best oral research presentation
- Invited speaker for webinars, symposiums and pod casts all over Europe with devotion to “How can we create a culture in orthopaedics where everyone can thrive and develop”

Session XII:

Osseointegration II

David B. Frumberg, MD, Moderator

Safety and Early Experience of Osseointegration Limb Replacement with Custom–Fit Implants

S. Robert Rozbruch, MD; Zachary Glassband, BA; Jason S. Hoellwarth, MD; Taylor J. Reif, MD
rozbruchsr@hss.edu

Question: Osseointegration limb replacement enhances mobility, balance, and proprioception and eliminates problems associated with socket mounted prostheses such as skin problems, ulcers, and pain. While osseointegration traditionally utilizes off–the–shelf implants with varying diameters and lengths, an ideal fit with the shape of the residual bone can be difficult to obtain in all cases. Additive manufacturing using electron beam melting (EBM) allows the production of precision osseointegration implants to achieve an optimal fit between the implant and bone. The purpose of this research is to describe the safety and early experience of osseointegration limb replacement with custom–fit implants.

Answer: We retrospectively reviewed all patients at our institution who underwent osseointegration with custom EBM 3D printed implants planned from a preoperative CT scan between May 2024 and March 2025, including transfemoral, transtibial, and transhumeral osseointegration procedures. The primary outcomes were intraoperative distal chip fracture and postoperative adverse events. Additional outcomes were patient–reported quality of life surveys (LD–SRS and PROMIS) outcome scores.

Results: Nineteen patients had unilateral osseointegration with EBM custom–fit implants (ALM, Scarborough, ME). Nine patients had osseointegration simultaneous with their index amputation, and 10 patients had revision of a traditional amputation for issues related to socket fitting (7), skin problems (7), pain (8), and mobility (8). Intraoperatively there was no reaming or broaching beyond the implant size. There were also no instances of intraoperative distal chip fracture, which was significantly different from our historical control cohort with off–the–shelf implants (0% custom–fit vs 21.2% off–the–shelf, $p = 0.032$). Postoperatively, all patients progressed to full weight bearing following a standard loading protocol without loosening. No implant fractures, deep infection, or unplanned surgeries have occurred with an average follow up of 6 months. There were large statistically significant improvements in patient reported outcomes scores (LD–SRS Total 3.0 ± 0.0 preoperatively vs 3.7 ± 0.6 postoperatively, $p = 0.004$; PROMIS Pain Intensity, 50.0 ± 8.1 preoperatively vs 41.8 ± 9.0, $p = 0.006$). Moreover, a significant increase in prosthetic use was observed in patients who initially presented with a prosthesis (prosthetic daily wear hours 8.9 ± 6.0 preoperatively vs 13.7 ± 2.1 postoperatively, $p = 0.038$).

Conclusions: Precision EBM custom–fit osseointegration implants avoid intraoperative distal chip fracture and reliably osseointegrate without loosening. Short term functional outcomes are similar to other press–fit osseointegration options and warrant longer follow up.

Femur and Tibia Press–Fit Osseointegration – A Comparison of Safety and Outcomes

Zachary Glassband, BA; Taylor J. Reif, MD; S. Robert Rozbruch, MD:
Jason S. Hoellwarth, MD
glassbandz@hss.edu

Question: Osseointegration (OI) for lower limb amputees confers improvement of patient quality of life, prosthetic use, and walking ability by eliminating socket related problems. However, the available literature has no studies focusing on the differences in safety and outcomes of patients that underwent transfemoral osseointegration as compared to those that underwent transtibial osseointegration. The purpose of this study was to directly compare the adverse events along with clinical and surveyed outcomes of these two patient groups.

Answer: Patients who had lower extremity osseointegration with a minimum of one year follow up at a single institution were reviewed. They were categorized into two groups, Femur or Tibia. Adverse events were recorded, and change of mobility and LD–SRS and PROMIS outcome scores were compared.

Results: There were 147 limb segments, and data is presented as Femur (83/147=56%) vs Tibias (64/147=44%). There were no significant differences in adverse event rates. Surgical debridement 14/83=17% vs 3/64=5%, p=0.131. Periprosthetic fracture occurred for 10/83=12% vs 0, p=0.057. Removal for loosening was 0 vs 2/64=3% (both were reimplanted), p=0.285. Removal for infection occurred for 2/83=2% vs 1/64=2%, p=0.812. Removal for implant fracture was 0 vs 1/64=2%, p=0.451.
Preoperatively, femur patients had worse mobility than tibia patients (6MWT 211.7±163.0 vs. 280.5±153.5 m, p=0.017) and wore their prosthesis fewer hours daily (7.5±6.4 vs 10.7±5.6 hours/day, p=0.008). Their preoperative LD–SRS and PROMIS scores were similar.
Postoperatively, 6MWT were similar (320.9±116.1 vs 404.3±71.7 m, p=0.201), though transfemoral osseointegration patients generally wore their prostheses for fewer hours daily (13.2±4.9 vs 15.2±2.7 hours/day, p=0.009). Both the femur and tibia groups significantly improved in all domains of the LD–SRS and PROMIS surveys. The tibia patients did improve to a greater magnitude than the femur patients for these surveys.

Conclusions: Press–fit osseointegration significantly improves the mobility and quality of life for both femur–level and tibia–level amputees. There is a similar rate of adverse events for both levels. Tibia–level amputees may experience an even greater improvement of quality of life than femur–level amputees.

Effect of BMI and Muscle Area Ratio on Complication Rate after Lower Extremity Osseointegration

Mohamed Abdelaziz Elghazy, MD; Zachary Glassband, MD; S. Robert Rozbruch, MD; David Otterburn, Taylor Reif, MD; Jason S. Hoellwarth, MD
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Question: Osseointegration (OI) entails attaching prosthetic components directly to the skeleton of the residual limb, thereby bypassing the need for a socket interface. Infections and soft tissue irritation are the most commonly reported complications. There is no literature directly assessing the impact of body mass index (BMI) or the relationship of the limb segment cross–sectional muscle area ratio regarding the rate of postoperative infections or reoperations. The aim of this study was to evaluate the effect of BMI and muscle mass ratio on the occurrence of adverse events after OI.

Answer: Patients who received lower extremity OI at a single institution with a minimum of one year follow up were retrospectively reviewed. They were categorized into Femur or Tibia level cohorts. Adverse events were defined as surgery to address infection, soft tissue refashioning, and periprosthetic fracture. The cross–sectional muscle area ratio was calculated from the preoperative CT scan cut at the level of the bone cut (Figure 1). First the entire perimeter of the skin was outlined, then the muscle was outlined separate from the total perimeter. The number of muscle pixels were divided by the total pixels of the limb's cross–section to calculate a muscle area ratio. The BMI and muscle area ratio were assessed for their association with postoperative adverse events.

Results: 118 limbs in 114 patients were included. For the 70 femurs, the average follow–up time was 24.9 months, BMI was 28.8 kg/m², and muscle ratio was 51.8%. For the 48 tibias, the averages were 27.0 months, 29.0 kg/m², and 73.2%, respectively. Within the femur cohort, 13 (19%) had surgical debridement for infection whereas 57 did not; there was no statistical difference in muscle area ratio (51.6±15.5% vs 52.5±17.7%, p=.857) or BMI (29.7±6.0 vs 27.4±5.3, p=.274). 11 (16%) had refashioning whereas 59 did not; there was statistical difference in muscle area ratio (42.0±17.0% vs 53.6±15.1%, p=.038) but not for BMI (31.1±4.8 vs 28.4±6.0, p=.100). Within the tibia cohort, 3 (6%) had surgical debridement for infection whereas 45 did not; there was no statistical difference in muscle area ratio (73.0±15.1% vs 75.1±15.3%, p=.792) or BMI (29.2±6.1 vs 27.2±3.7, p=.328). 1 (2%) had refashioning whereas 47 did not; statistical comparison was not performed for muscle ratio (90.1% vs 72.8±14.9%) nor BMI (27.9 vs 29.1±6.0) due to the singular event precluding statistical appropriateness. One femur (1%) and one tibia (1%) implant were removed for infection; statistical comparisons were not performed due to too few events.

Conclusions: There was a statistically significant association of decreased muscle ratio (increased fat ratio) with soft tissue revision for femur patients, but not tibia. There is no recognized association of BMI for soft tissue revision for femurs or tibias, and no association of BMI or muscle ratio with femur infection debridement. Additional research is needed to identify predictive risk factors for debridement. It appears beneficial to surgically reduce redundant fat and skin for femur–level patients having osseointegration to avoid subsequent soft tissue refashioning.

Table 1: Results of Muscle mass ratio and BMI in the groups with and without complications in both femur and tibia OI.

	No Surgical Debridement	Surgical Debridement	P
Muscle Mass Ratio			
Total	61% ± 18.6%	57.5% ± 19.4%	0.484
Femur	51.6% ± 15.5%	52.5% ± 17.7%	0.857
Tibia	73% ± 15.1%	75.1% ± 15.3%	0.792
BMI			
Total	29.2 ± 6	27.3 ± 4.9	0.156
Femur	29.1 ± 6	27.4 ± 5.3	0.274
Tibia	29.2 ± 6.1	27.2 ± 3.7	0.328

	Skin Refashioning	No Skin Refashioning	P
Muscle Mass Ratio			
Femur	42% ± 17%	53.6% ± 15.1%	**0.038**
Tibia	90.1% ± N/A	72.8% ± 14.9%	N/A
BMI			
Femur	31.1 ± 4.8	28.4 ± 6	0.1
Tibia	27.9 ± N/A	29.1 ± 6	N/A

	Nerve Surgery	No Nerve Surgery	P
Muscle Mass Ratio			
Femur	54.5% ± 19.2%	51.6% ± 15.7%	0.736
Tibia	69.6% ± 15%	73.5% ± 15.1%	0.618
BMI			
Femur	27 ± 5.7	28.9 ± 5.9	0.481
Tibia	28 ± 5.1	29.1 ± 6.1	0.68

Hall of Fame

Stuart A. Green, MD

Dr. Stuart Green is the son, father, and first cousin of orthopaedic surgeons. He trained in orthopaedic surgery at The Hospital for Joint Diseases in New York (Now NYU Langone Orthopaedics). After an infectious diseases fellowship at the University of California San Diego, Dr. Green joined the Greater Long Beach Orthopaedic Group where he worked for 50 years, while also heading the Osteomyelitis Service at Rancho Los Amigos National Rehabilitation Center. He now functions as an orthopaedic specialist at the Long Beach Veterans Administration Medical Center (walking from home!) and as a Professor in the University of California Irvine's Department of Orthopaedic Surgery. In 1981, his first book, Complications of External Skeletal Fixation, pointed the way towards the safe application of external fixators in orthopaedic care, reintroducing the devices into an orthopedist's armamentarium after a hiatus of more than 30 years.

In 1986, with Dr. David Seligson, Dr. Green developed the first retrograde femoral nail, inserted via the knee joint. In 1987, he crossed the Iron Curtain becoming the first American to visit Siberian surgeon G.A. Ilizarov and later helped Ilizarov with publications in the Western medical literature. Dr. Green subsequently modified Ilizarov's technique by substituting half-pins for tensioned wires in the circular external fixation frame—the RANCHO technique. More recently, Dr. Green has been instrumental in developing the PRECICE™ Intramedullary Lengthening Nail.

Dr. Green has been president of both The Association of Bone and Joint Surgeons and the Limb Lengthening and Reconstruction Society, which he co-founded with Dr Dror Paley. Stuart Green has long been interested in the history of medicine, medical ethics, professionalism, and related topics. Starting in 1999, he published a series of articles dealing with various issues related to the anthropology, history and sociology of his profession. His interest in our country's colonial past resulted in original research on the repeal of the Stamp Act in 1765, published in the prestigious Pennsylvania Magazine of History and Biography. He has written a biography of Benjamin Franklin (Dear Doctor Franklin) focusing on Franklin's interest in medical and scientific matters.

These publications led to an assignment as a bimonthly columnist on “Art in Science” for Clinical Orthopaedics and Related Research, as well as an appointment to the Editorial Board of AAOS NOW.

Dr. Green and Adrienne, his wife of 60 years, have two children and five grandchildren. His hobbies include travel, photography, bicycling, and swimming. Stuart Green has had two gallery photography exhibits in Los Angeles. His photographywebsite is stuartgreenphotos.com.

John E. Herzenberg, MD

Dr. John Herzenberg is a native of Springfield, Massachusetts, USA. He attended high school for three years in Kibbutz Kfar Blum in Israel, hence his fluency in the Hebrew language. He then studied medicine at Boston University School of Medicine, completed orthopedic residency at Duke University, and a pediatric orthopedic fellowship at University of Toronto's Hospital for Sick Children. He was an AOA North American Travelling Fellow and American British Canadian Travelling Fellow. He travelled to Kurgan, USSR, and Lecco, Italy to study the Ilizarov method. He was on the full time faculty at University of Michigan as Assistant Professor (1986–1991), University of Maryland as Associate and then Full Professor (1991–2001), and at Sinai Hospital since 2001.

He is a Clinical Professor at the University of Maryland, and was formerly the Director of the International Center for Limb Lengthening at Sinai Hospital's Rubin Institute for Advanced Orthopedics, and Head of Pediatric Orthopedics for Sinai Hospital.

He is a former President of the Limb Lengthening and Reconstruction Society and former President of the Maryland Orthopedic Society. He is a member of AAOS, POSNA and LLRS. He specializes in the treatment of adults and children with clubfoot, congenital abnormalities, limb length discrepancy, joint contractures, non–unions, malunions, bone deformity, and bone defects. He organizes the Baltimore Limb Deformity Course, now in its 35th year, and travels nationally and internationally as a speaker. He co–authored the Multiplier App, the Art of Limb Alignment, and Art of Limb Alignment – TSF. He has co–authored over 190 PubMed listed papers, over 50 book chapters, and various books, including editing The Principles of Deformity Correction (Springer, 2002), and Art of Limb Alignment – Taylor Spatial Frame, and Art of Limb Alignment (multiple editions). In 1997, Dr. Herzenberg helped revive the Ponseti method and promulgate it world–wide to become the standard of care for clubfoot. He co–developed an internal magnetic powered lengthening nail as an alternative to external fixators for limb lengthening.

Dr. Herzenberg is married to Merrill Chaus, RN, MPH. They have three grown daughters: two nurses, and an architect. He is an honorary member of the Israeli Orthopedic Association and operates there yearly in various hospitals. Since 1998, he and his family have volunteered yearly with Operation Rainbow, providing orthopedic surgery to underprivileged children and adults in Nicaragua, Colombia, Ecuador, Uganda, Ethiopia, Liberia, Nepal, Honduras, and Haiti. He has recently volunteered in two active war zones: Ukraine, and Israel. In recognition of sustained international service, he was given POSNA's 2016 Humanitarian Award. Most recently, he is being inducted into the
inaugural class of the LLRS Hall of Fame. Dr. Herzenberg recently retired (summer 2023) from active clinical practice, and has relocated to Boulder, CO, where he and Merrill are full time grandparents, as of August 2023. Even more recently, they have another grandson in Miami, so they now travel back and forth from Miami to Colorado. Dr. Herzenberg's current status is Emeritus Faculty at Sinai Hospital, and he continues to be involved in teaching, research, publishing, the annual Baltimore Limb Deformity Course, and organizing international service missions to the Developing World.

Dror Paley, MD

Dror Paley, MD, FRCSC is the CEO, Founder, and Medical Director of the Paley Orthopedic and Spine Institute in West Palm Beach, Florida, from 2009 to present, and the Founder of the Paley European Institute in Warsaw, Poland, 2018, Paley Middle East Clinic, Abu Dhabi, UAE 2023 and Instituto Paley Latino America
2024 in Medellin, Colombia. The Paley Institute is the world's largest medicaltourism center, treating patients from 110 countries and all 50 states. He speaks, lectures and reads and writes in 6 languages. He was the Founder and Director of the Rubin Institute for Advanced Orthopedics, Baltimore, 2001–2009, and Professor & Chief of Pediatric Orthopedics at the University of Maryland,
1987–2001, and Associate Staff at Hospital of Sick Children, Toronto, Canada, 1987.

He did three years of subspecialty fellowship training in Pediatric Orthopedics, Hand Surgery, Trauma Surgery, and Limb Lengthening and Reconstruction Surgery,1985–87. He completed his orthopedic surgery residency at the University of Toronto 1980–1985 and his internship at Johns Hopkins 1979– 80. He received his medical degree from the University of Toronto Medical School, Toronto, Canada, in 1979. He was Professor of Orthopedics at University of Maryland 1987–2001. He was adjunct Professor of Orthopedic Surgery and consultant at the Hospital for Sick Children, University of Toronto, from 2010–2014. He currently holds academic appointments as a Professor of Orthopedics at the University of Vermont and at Florida Atlantic University. He sits on the Board of Governors of St. Mary's Medical Center. He has performed 25,000+ surgeries. He runs the Paley and unLIMBited Foundations and does mission trips around the world.
Dr. Paley is internationally recognized for his expertise in limb lengthening and reconstruction. He trained under the guidance of Prof. Gavril Ilizarov during multiple visits to Kurgan, Soviet Union. Dr. Paley introduced the Ilizarov method to the US and Canada in 1987 and subsequently was instrumental in the introduction and dissemination of the Ilizarov method in Northern Europe, South

America, across Asia, Australia and New Zealand and parts of Africa. He was the Founder and first president of the Limb Lengthening and Reconstruction Society in 1989 and of the International Limb Lengthening and Reconstruction Society in 2015. He is the recipient of numerous awards, including Gubernatorial Citation 1990, Pauwel's Medal in Clinical Biomechanics 1997, Best paper/poster award by SICOT, AAOS, POSNA, AORS; best illustrated medical textbook 2003; Health Professional of the Year 2011, Health Hero of the Year 2013, Florida Most Influential Business Leader 2019, 20, 21, 22, 23 and was named a Living Legend and most influential business leader in Palm Beach by the Palm Beach Illustrated.

He served as the Orthopedic Surgeon to the White House from 2017 to 2021 and was reappointed again in 2025. He has published 193 peer– reviewed articles, 73 book chapters, 50 video productions and 9 books; most notably: Congenital Femoral Deficiency 2023, and Principles of Deformity Correction, Springer (2002, 2005). The CORA method of deformity analysis in this text has become the gold standard for deformity planning in orthopedics.Dr. Paley developed over 100 surgical procedures including: SUPERhip, SUPERknee, SUPERankle, SHORDT, Paley Weber patelloplasty, ulnarization, Paley Rotationplasty, modified Judet quadricepsplasty, Paley Cross Union for CPT, MHE forearm interosseous correction, four–segment achondroplasia lengthening, and many others. He had had an interest in Perthes disease since 1989 when he first developed the method of articulated hip distraction for Perthes. He has also developed a method to reshape the femoral head using Femoral Head Reduction Osteotomy. He developed the Multiplier method of predicting leg length discrepancy and timing of epiphysiodesis, now available using the Android and iOS app Paley Growth Multiplier App.

He lives with his wife, Jennifer, and has four grown children, Benjamin, Jonathan, Aviva, and Daelan; three grandchildren, Dalia, Jack and Lev. His hobbies include reading history, skiing, road and mountain biking, rock climbing, and scuba diving.

Posters

Please visit the poster display in The Stenton

Outcomes of Elective Transtibial Amputation for Foot and Ankle Problems

Austin T. Fragomen, MD; Mohamed Abdelaziz Elghazy, MD; Zachary Glassband, BA; Taylor J. Reif, MD; Jason S. Hoellwarth, MD; S. Robert Rozbruch, MD
FragomenA@hss.edu

Question: Some patients with foot and ankle deformity, chronic infection, or intractable pain elect for transtibial amputation instead of reconstruction surgery. However, unlike limb salvage patients, the outcome of elective amputation for this group is not well studied. The aim of this study was to evaluate the clinical outcomes and patient satisfaction after undergoing elective transtibial amputation with conventional socket rehabilitation.

Answer: Medical records were reviewed to identify patients who had transtibial amputation instead of reconstruction for reasons of deformity, pain, or infection. Exclusion criteria were less than one year follow−up, patients who received tibial osseointegration implants, and amputation due to tumors, vascular insufficiency or acute traumatic amputation. The primary outcome was adverse events. Secondary outcomes were postoperative−only patient−reported surveys (LD−SRS and PROMIS); preoperative surveys were not administered. Patients also rated their satisfaction from 1 (very unsatisfied) to 5 (very satisfied) and were asked if they would have the same management again (5=definitely yes, 1=definitely no).

Results: Fourteen patients were included in this study with an average follow up of 29.1±20.2 months. All patients obtained a socket prothesis for rehabilitation. The causes for amputation were Charcot foot and ankle (n=6), CRPS (n=3), chronic foot infection (n=2), and complex deformity (n=1). Two patients had bilateral amputation, one for bilateral CRPS, and the other for bilateral congenital clubfoot. Four patients had surgical debridement after primary amputation. One patient had a displaced fracture of the lateral femoral condyle three years later managed with open reduction and internal fixation. The clinical outcome scores of LD−SRS and PROMIS are listed in table 1. LD−SRS scores averaged nearly a 4 (out of 5) across all domains. Of 11 patients who responded to satisfaction surveys, 2 (18%) were satisfied and 9 were very satisfied (82%). Of those same 11, 9 (82%) would definitely have the same procedure again, 1 (9%) would probably do it again, and the one patient who was unsure expressed he would have considered osseointegration if he were to do it again.

Conclusions: For patients with unilateral complex foot and ankle deformities, elective transtibial amputation with socket prosthesis rehabilitation can provide high satisfaction with the outcomes with a low risk profile. Patients who are not satisfied may benefit from consultation regarding osseointegration.

Dynamic Interfragmentary Compression Through a Tibial Intramedullary Nail Compared to Backslapping Alone: A Biomechanical Analysis

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Question: We sought to investigate the amount of interfragmentary compression that can be obtained in a transverse tibia fracture model with backslapping alone (BS) versus the intramedullary nail's dynamic internal compression (IC) mechanism and if that compression is maintained after loading. The hypothesis is that IC will achieve and maintain greater compression of a transverse tibial fracture compared to BS.

Answer: A biomechanical transverse diaphyseal tibia fracture model was used. A [redacted] nail was inserted. Tibias were divided into two groups (n=10/group). Fracture compression was obtained either by BS or use of the nail's IC device. Specimens were loaded for 135,000 cycles of 700N @ 3Hz to simulate three months of weightbearing. Interfragmentary pressure measurements were recorded at procedure completion (pre−cycling) and after loading (post−cycling). Compression at each stage was compared between BS and IC groups as well as changes in compression after loading. A subanalysis was performed to compare outcomes between the T2A and S+N nails.

Results: Significantly greater compression was generated pre−cycling in the IC compared to the BS group (394.4N vs. 94.7N, $p < 0.001$) and maintained post−cycling (331.6N vs. 67.5N, $p < 0.001$). Both groups experienced statistically significant loss of compression during the cycling process (BS, 28.7% loss, IC, 15.9% loss, $p < 0.05$ each. On subanalysis, IC of the T2A nail demonstrated no significant loss of compression after cycling (5.7%, p=0.148) and also exhibited greater post−cycling compression than that obtained by IC of the S+N nail (416.6N vs 246.6N, p=0.032). However, the S+N BS group generated and maintained significantly more compression than the T2A BS group (pre−cycling: 168.3 N vs. 21.1 N, p=0.001; post−cycling: 120.2N vs 14.9N, p=0.004).

Conclusions: Our test results suggest that intramedullary IC devices generate and maintain greater interfragmentary fracture compression than traditional BS techniques alone. However, some compressive force is lost after loading regardless of compression technique utilized. Differences in compressive force were observed between nail manufacturers with both techniques, which suggests that nail geometry may contribute to maintaining interfragmentary fracture compression.

Motorized Intramedullary Limb Lengthening: Management of and Risk Factors for Fracture

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Question: Motorized intramedullary lengthening nails (MILN) are a common implant to provide limb lengthening. While there has been substantial literature written about MILN use and complication management, the complication of fractures related to limb lengthening with a MILN has never been the focus of investigation. This research aims to describe our practice's incidence and management of fractures in patients who had MILN surgery, and also evaluate potential risk factors.

Answer: Medical records of 541 MILN limb segments were retrospectively reviewed, identifying 18 patients (3%) who sustained fractures (all unilateral). The primary outcomes were anatomic location of the fracture, management technique, and time to weight bearing as tolerated. Additionally, comparison of demographic data was performed between lengthening patients that fractured and those that did not in order to evaluate the potential risks for fracture.

Results: Fourteen fractures were in the lengthened bone: seven (50.0%) were provided intramedullary nailing, three (21.4%) were managed with protected weight bearing (two with supportive orthosis), two (14.3%) had plate and screw fixation, one (7.2%) had intramedullary nailing with an external fixator, and one (7.2%) had intramedullary nailing with plate and screw fixation. Four fractures were in the ipsilateral limb but different bone: one femoral lengthening patient had a subsequent tibia fracture managed by external fixation, one tibia lengthening patient had a subsequent femur fracture managed with plate and screw fixation, one femur lengthening patient had a subsequent fibula fracture managed with protected weight bearing, and one femur lengthening patient had a subsequent metatarsal fracture managed with protected weightbearing. All patients regained full function of their lengthened limb following healing of the injury, notably full weight bearing independent walking without restriction. No patients experienced a permanent reduction of function due to the fracture. Risk factors significant ($p<.05$) for fracture after MILN lengthening were: female sex, unilateral lengthening, and a shorter total lengthened amount (it is noted that a potential confounder is the large representation of men who had bilateral stature lengthening).

Conclusions: Fracture after limb lengthening surgery is an uncommon complication. Multiple common fracture care options are successful in achieving patient healing and resumption of activities without limitation.

Evaluating In Vivo Efficacy of Enzymatic Biofilm Dispersal from Orthopaedic Implants

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Question: Bacterial biofilms are difficult to treat etiologies of implant related orthopaedic infections. When implant retention is desired, eradicating biofilm in vivo can be especially difficult. Recent in vitro studies from our lab have shown that debridement with bromelain, an enzyme derived from pineapple stem, can effectively disperse biofilms from surgical grade orthopaedic screws. This effect in vivo is important to consider given the persistent "culture−condition" that a living organism provides to bacteria. The purpose of this study was to determine how well in vivo conditions replicate in vitro biofilm dispersal results using bromelain based enymatic debridement.

Answer: Stainless steel bone pins were incubated at 37„*f* in tryptic soy broth with 10% fetal bovine serum and inoculated with methicillin−resistant Staphylococcus aureus (MRSA) clinical isolate BAA−1683. Biofilm washed pins were first infected in the same fashion and then soaked in 1000 Î¼g/mL bromelain for 20 minutes and washed in phosphate buffered saline (PBS). A second set of pins prepared as above were placed into the intramedullary space of adult Sprague Dawley rats for 7 days and explanted. All pins were fixed and stained with Sytox Orange and imaged at 100x magnification using confocal microscopy. €‹ The bacterial burden was quantified using SlideBook 5.0 software (3i) including size exclusion relative to host cells. The explanted femurs were imaged using micro−CT to determine bone volume ratio. Statistical comparisons between exposures were done using one−way analysis of variance.

Results: The in vitro infected pins (n=6) exhibited a mean bacterial burden of 560.83 CFU, while the in vivo infected pins (n=3) displayed a higher mean burden of 873.7 CFU (p=0.3944). The bromelain pre−washed in vivo pins (n=3) had a mean bacterial burden of 819.3 CFU compared to the in vitro bromelain−washed pins (n=4), demonstrating a vastly lower bacterial burden of 96.5 CFU (p=0.0195). Micro−CT results for infected pins demonstrates lower bone volume to total volume ratio (BV/TV), consistent with the osteolytic properties of the used clinical isolate. Contrasting BV/TV findings from the bromelain washed pins and uninfected pins indicated that these pins did not have the same osteolytic response in the bone and a consistent "shell" was evident around the implant.

Conclusions: The data indicate that while bromelain shows promise as a viable option for cleaning infected orthopedic implants, in vitro conditions do not adequately allow for reliable study of in vivo potential. Although the bromelain washes effectively reduced the bacterial burden in vitro, low bacterial levels in vivo were not maintained following seven days of implantation which is essentially a physiologic culture condition. Base on micro−CT results where the bromelain washes pins did allow for some osteoblastic response, the resurgence of bacterial was likely delayed by the reduced burden of bacterial prior to implanting the pins. These findings are an important reminder that following any method of debridement, persisting bacteria in wounds and on bone/implants do have the opportunity to rebound as persistent infection.

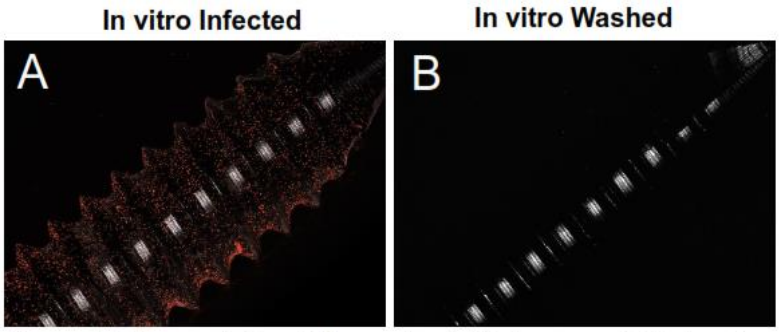

Figure 1: Representative 100x confocal 3D images of (A) in vitro infected stainless steel bone pin and (B) in vitro bromelain washed stainless steel bone pin.

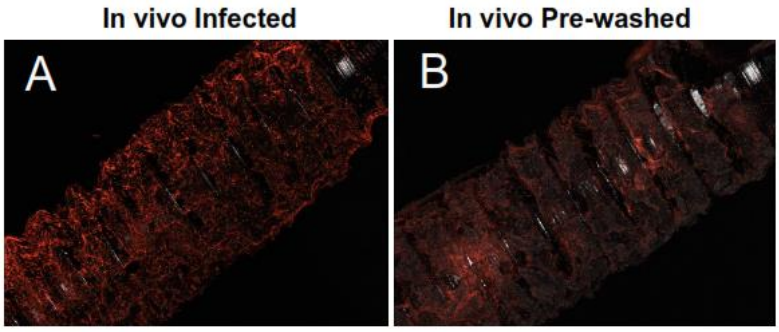

Figure 2: Representative 3D images of (A) in vivo infected stainless steel bone pin and (B) in vivo bromelain pre-washed stainless steel bone pin.

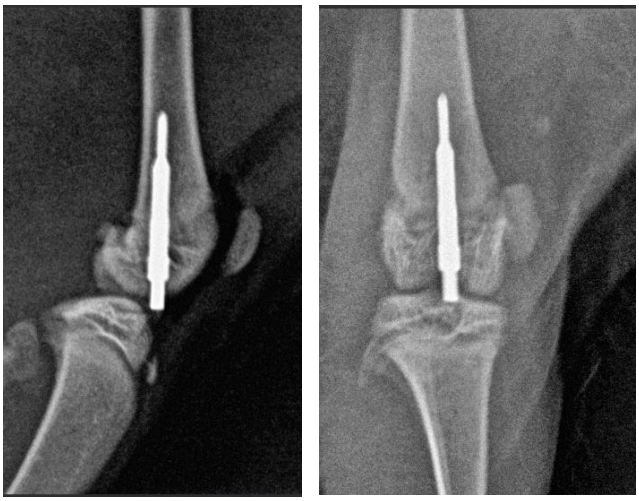

Figure 3: Representative AP and lateral radiographs of implanted pins

Use of Ankle Distraction Frames in Treatment of Pilon Fractures: Technical Trick

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Question: Tibiotalar arthrodiastasis, or ankle distraction arthroplasty, can facilitate cartilage repair, restore joint space, and improve range of motion for ankle arthritis. We describe an adaptation of this technique for acute treatment of pilon fractures to facilitate immediate weight bearing, early range of motion, maintenance of articular reduction, and chondroprotection due to distraction and motion.

Answer: Four patients underwent open reduction internal fixation (ORIF) of pilon fractures (AO/OTA 43B or C). An ankle arthrodiastasis frame was applied after definitive internal fixation. All patients were treated by a single orthopedic trauma fellowship trained surgeon at a large academic hospital. Patients had the ankle locked in a plantigrade position for 2 weeks while the surgical incisions healed and were permitted range of motion as tolerated thereafter. All patients were permitted weight bearing as tolerated after frame application. The frames were removed at 3 months postoperatively.

Results: The mean age was 33.3 (range 23−47) and three patients were male. Three patients had initial ankle−spanning external fixation using a ringed external fixator followed by modification for ankle distraction after ORIF. One patient had the distraction frame applied after ORIF; no initial spanning was performed. One patient had a contralateral injury that precluded weightbearing on that leg while the others had isolated injuries. Follow up ranged from 3−27 months. Mean PROMIS scores for physical function and pain interference were 34 and 62, respectively, at 3 months for all patients, and 44 and 61 at > 1 year follow−up for two patients. There were no complications, related to the frame or otherwise. One patient underwent removal of hardware at 1 year.

Conclusions: Distraction arthroplasty in the acute treatment of pilon fractures allows for early weight bearing, immediate ankle range of motion, and the potential biologic and biomechanical properties of arthrodiastasis on articular cartilage and joint function.

Differences in Treatment Course Between Upper and Lower Extremity Nonunions

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Question: Are there differences in the treatment courses and outcomes for nonunions in different areas of the body?

Answer: We conducted a retrospective analysis of patients who underwent surgical treatment for nonunion or malunion between November 2015 and June 2024 at a single center. Included patients were over 18 at the time of surgery, had at least 90 days of follow–up after treatment, and had injury from iatrogenic or traumatic causes. Variables recorded included nonunion/malunion location (between upper extremity and lower extremity), patient demographic details, whether union was achieved within 1 year and within 2 years, time to union and length of hospital stays in those achieving union, and presence of post–operative complications within 90 days of definitive surgery (including severe medical complications, rehospitalization, unplanned reoperation, etc.). Associations between injury location and rates of union within one year and presence of post–operative complications were analyzed using Chi–Squared or Fisher Exact Test. Associations between injury location and time to union and length of stay were analyzed using the Mann–Whitney U–test.

Results: 208 patients were included in the analysis, with 171 having at least 1 year of follow–up, 156 having at least 2 years of follow–up, and 143 being followed–up until union was achieved. 45.2% of lower extremity nonunions united within 1 year, compared to 83% of upper extremity nonunions ($p < 0.001$). After 2 years, 87.5% of lower extremity injuries had united while 100% of upper extremity nonunions had united ($p = 0.013$). Lower extremity injuries had a median time to union of 288 days, compared with 121 days for upper extremity injuries, respectively ($p < 0.001$). Median length of stays were 6 and 0 days for lower and upper extremity injuries, respectively ($p < 0.001$). Injury location was not significantly associated with differences in postoperative complications, rates of rehospitalization, and unplanned reoperations in the 90 days after the definitive surgery.

Conclusions: Nonunions and malunions in the lower extremity are associated with longer times to union, longer hospital stays, and less union within one year of definitive surgery compared to similar injuries in the upper extremity. While injuries were more likely to unite within 2 years, there was still a significant difference in union rates between upper and lower extremity nonunions.

Evaluation of Outcomes by Surgical Technique for Aseptic Nonunion and Malunion

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Question: To compare the efficacy of open reduction internal fixation (ORIF), intramedullary nailing (IMN), and external fixation in the correction of aseptic nonunion and malunion.

Answer: This retrospective cohort study included adult patients undergoing corrective surgery for chronic aseptic nonunion or malunion at a single academic center between October 2014 and May 2024. Demographic (age, sex, race, ethnicity, insurance, etc.) and clinical course details were collected via chart review. Postoperative outcomes (union, complication, rehospitalization, and reoperation rates) were analyzed for patients with at least 90 days of follow–up after definitive surgery. Statistical analysis was performed using R (version 4.4.0). Fisher's exact test was employed to assess significance for categorical variables, and Kruskal–Wallis test was used for continuous variables.

Results: One hundred sixty–eight patients were identified (ORIF 57.4%; IMN 37.5%; external fixation 4.8%). ORIF patients had a greater median age (60 vs 47 vs 49 years, $p=0.004$), and all external fixation patients were male ($p=0.005$). Patients treated with ORIF had significantly decreased median time from presentation to definitive surgery compared to IMN and external fixation (54 vs 133 vs 179 days; $p<0.001$) and decreased total length of stay across all admissions (1 vs 4 vs 3 days, $p<0.001$). Median time to union was significantly shorter for ORIF compared to IMN and external fixation (176.5 vs 309 vs 461 days; $p<0.001$). Among patients with at least one year of follow–up or union within one year (66.7%), 79.4% of ORIF patients achieved union within one year compared to 51.2% for IMN and 25.0% for external fixation ($p<0.001$). However, among patients with at least 90 days follow–up (83.9%), no differences were observed with respect to postoperative complications, rehospitalization, or unplanned return to operating room, and there were no differences in loss to follow–up rates among all patients.

Conclusions: Patients undergoing ORIF for management of aseptic nonunion or malunion exhibit significantly decreased time to definitive surgery, total length of stay, and time to union compared to IMN and external fixation, along with higher one–year union rates, suggesting the potential to expedite the recovery process and curtail resource utilization and patient burden.

Pelvic Osseointegration for Unilateral Hip Disarticulation: A Case Series

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Question: Lower–limb amputees face significant challenges to rehabilitate. Traditional socket prostheses (TSPs) have been the standard for artificial limb attachment but are often associated with discomfort and mobility restrictions, leading to limited wear time and prosthesis abandonment rates of 25–57%. Hip disarticulation patients face further disability with increased TSP challenges. Fewer than half tolerate a prosthesis. Pelvic osseointegration is an emerging solution for patients with unilateral hip disarticulation. This study aimed to evaluate (1) the rate of complications following the primary procedure, (2) changes in prosthesis wear time and mobility, and (3) patient–reported perceptions of prosthesis use.

Answer: A retrospective review of our osseointegration registry identified all patients who underwent pelvic osseointegration at least two years prior. Mobility outcomes, prosthesis wear time, patient–reported satisfaction, and complications were analyzed.

Results: Five patients (4M, 1F; mean age 51.8 years, range 37–63) underwent pelvic osseointegration. Three patients were initially wheelchair–bound. At follow–up, three of these became ambulators: two were ambulating without assistive devices, and one was a home ambulator using two crutches as aid. One patient (BMI 44.3) remained wheelchair–dependent due to insufficient strength. One patient experienced complications and was lost to follow–up.

Conclusions: Pelvic osseointegration can significantly improve mobility and prosthesis use in appropriately selected patients. However, higher BMI may be a risk factor for poorer mobility outcomes. Future studies should further assess long–term functional outcomes and patient–reported satisfaction.

Distal Humerus Nonunions: Surgical Outcomes and Risk Factors for Recalcitrant Nonunion

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Question: Distal humerus nonunion develops following fracture fixation in 4–25% of cases. Current literature on distal humerus nonunions consists of small, single–center, retrospective case series. No studies have investigated risk factors of distal humerus nonunion surgery failure. The purpose of this study is to describe outcomes after distal humerus nonunion surgery in a multicenter series of patients and to identify risk factors of nonunion surgery failure.

Answer: We performed a retrospective analysis on a database of 30 surgically treated aseptic distal humerus nonunions from 7 level I trauma centers between 2007–2019. Bivariate analyses were performed to evaluate the likelihood of nonunion surgery success based on patient demographics, comorbidities, fracture–related characteristics, use of bone graft/bone graft substitutes, and postoperative complications.

Results: Of the 30 distal humerus nonunions, we found that 7 (23.3%) failed to unite following surgery. Twelve patients (40.0%) experienced one or more postoperative complications (infection, deep vein thrombosis, hardware failure, reoperation, and/or readmission). Complications were associated with nonunion surgery failure ($p=0.009$). All 7 patients that developed recalcitrant nonunion initially sustained an open distal humerus fracture. The use of bone graft or bone graft substitute was not associated with recalcitrant nonunion ($p=0.22$ and $p=0.62$ respectively). Patient age, body mass index, smoking status, diabetes, and initial AO/OTA fracture classification were not associated with the nonunion repair success rate.

Conclusions: This multicenter series challenges the previously described >95% union rate following distal humerus nonunion surgery. Our data suggest that an initially open distal humerus fracture may increase the risk of recalcitrant distal humerus nonunion. Postoperative complications were associated with distal humerus nonunion surgery failure, however modifiable risk factors like bone graft use and smoking did not influence the success rate of nonunion surgery in this study. These findings can be used to give patients an improved expectation of results and complications following distal humerus nonunion surgery. Investigation into methods for improving the success rate of distal humerus nonunion surgery is warranted.

Outcomes of Elective Transtibial Amputation with Osseointegration for Foot and Ankle Problems

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Question: Some patients with foot and ankle deformity, chronic infection, or intractable pain elect for transtibial amputation instead of reconstruction surgery. Recently, press–fit titanium transcutaneous osseointegration nailing (TiTON) has been introduced which entails attaching prosthesis directly to the skeleton to bypass the need of a socket. Most osseointegration literature focuses on patients who were existing amputees. The aim of this study was to evaluate the clinical outcomes and patient satisfaction after undergoing elective transtibial amputation with simultaneous primary osseointegration.

Answer: Retrospective review was performed of all our osseointegration patients who had a primary tibia amputation (rather than existing amputation) with simultaneous osseointegration (rather than osseointegration performed at a different surgery). The primary outcome was adverse events. Secondary outcomes were patient–reported surveys (LD–SRS and PROMIS). Patients also rated their satisfaction from 1 (very unsatisfied) to 5 (very satisfied) and were asked if they would have the same management again (5=definitely yes, 1=definitely no).

Results: Twelve patients were included, with an average follow up of 26.0±15.6 months. The causes for amputation were posttraumatic complications of chronic painful deformity and arthritis (n=4), CRPS (n=2), failed ankle fusion (n=1), chronic hindfoot osteomyelitis with diabetic neuropathy (n=1), foot drop and neurogenic pain after traumatic brain hemorrhage (n=1), dislocation of revision total ankle replacement with total talus (n=1), nonunion of supramalleolar osteotomy with hx of neurofibromatosis and club foot surgeries (n=1), and Maffuci syndrome with hx of multiple surgeries of enchondroma and hemangioma excision (n=1).

Two patients had subsequent surgical debridement to address infection; there were no other postoperative adverse events. Multiple PROMIS domains significantly improved: Global Physical Health, Pain Interference, and Physical Function. All LD–SRS domains significantly improved except for the mental health domain (table 1). All patients were satisfied (50%) or very satisfied (50%) with their limb management. All patients stated they would have the same surgery again.

Conclusions: For patients with unilateral complex foot and ankle deformities, elective transtibial amputation with simultaneous osseointegration confers significant quality of life benefits and high satisfaction, with a very good safety profile. This treatment option seems very reasonable to offer well informed patients.

Correction of Ulnar Deformity in Pediatric Patients with Multiple Hereditary Exostoses for the Treatment of Radiocapitellar Instability

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Question: What are the clinical and radiographic results of acute ulnar osteotomy to treat radiocapitellar instability in pediatric patients with multiple hereditary exostoses (MHE)?

Answer: A retrospective chart review of all patients who underwent an osteotomy of the ulna was performed. Patients were included if they had a diagnosis of MHE, were skeletally immature at the time of surgery, were treated with an acute osteotomy over an intramedullary nail and their radial head was not dislocated preoperatively. Patients were excluded if they did not meet the minimum two−year follow−up. Radiographic measurements including percent ulnar length (PUL), total radial bow (TRB), total ulnar bow (TUB) were recorded and compared at the preoperative, immediate postoperative and final follow−up time intervals using Friedman two−way ANOVA by ranks followed by Dunn's test with Bonferroni correction. Radiocapitellar joint status was analyzed with Fisher's exact test at each time interval. A secondary analysis was performed on all forearms regardless of follow−up to evaluate for complications.

Results: Twenty upper extremities (13 male/7 female) met the 2−year minimum follow−up requirement. The mean age at the time of surgery was 8.8 years (±3.1 years) and mean follow−up was 3.4 years (±1.0 years). Twelve radiocapitellar joints (60%) were subluxated on the preoperative images. Thirteen ulnas had plate in addition to the intramedullary fixation; 7/13 had the plates removed during the follow−up period.

Preoperative pronation measured 70 degrees (IQR 51 degrees) and supination measured 73 degrees (IQR 41 degrees). There was no significant improvement at final follow−up for pronation (68 degrees [IQR 31 degrees], $p = 0.3929$) or supination (88 degrees [IQR 30 degrees],$p = 0.6373$). PUL demonstrated no significant improvement with deformity correction (preoperative: 105%, $p=0.0863$). TUB significantly improved overall improvement from 19.6 degrees preoperatively to 4.5 degrees at final follow−up ($p<0.0001$) with a large effect size ($W=0.824$). TRB did not show any significant change (preoperative: 16.5 degrees, $p=0.4240$). All radiocapitellar joints were reduced on the immediate postoperative films. All but one radial head was reduced on final follow−up imaging which was a significant improvement compared to preoperative films ($p<0.0001$, OR 26.0, CI 3.0 − 1270.0). Figure 1 demonstrates the improvement of final follow−up TUB/PUL compared to the preoperative values. There is a left shift away from the instability line which has been previously published.

A secondary analysis of all forearms that underwent acute ulnar osteotomy was performed to assess complications. 50 forearms in 44 patients were included. The mean age at the time of surgery was 8.9 years (±3.1 years) and the mean follow−up time was 1.8 years (±1.6 years). There were 9 (18%) complications. Two radiocapitellar joints subluxated postoperatively: one from recurrence of the ulnar bow in a patient who was 2.5 years old at the time of the index procedure and one from a proximal ulnar osteochondroma causing a mass effect; both have been indicated for surgery.

Correction of Ulnar Deformity in Pediatric Patients with Multiple Hereditary Exostoses for the Treatment of Radiocapitellar Instability *continued*

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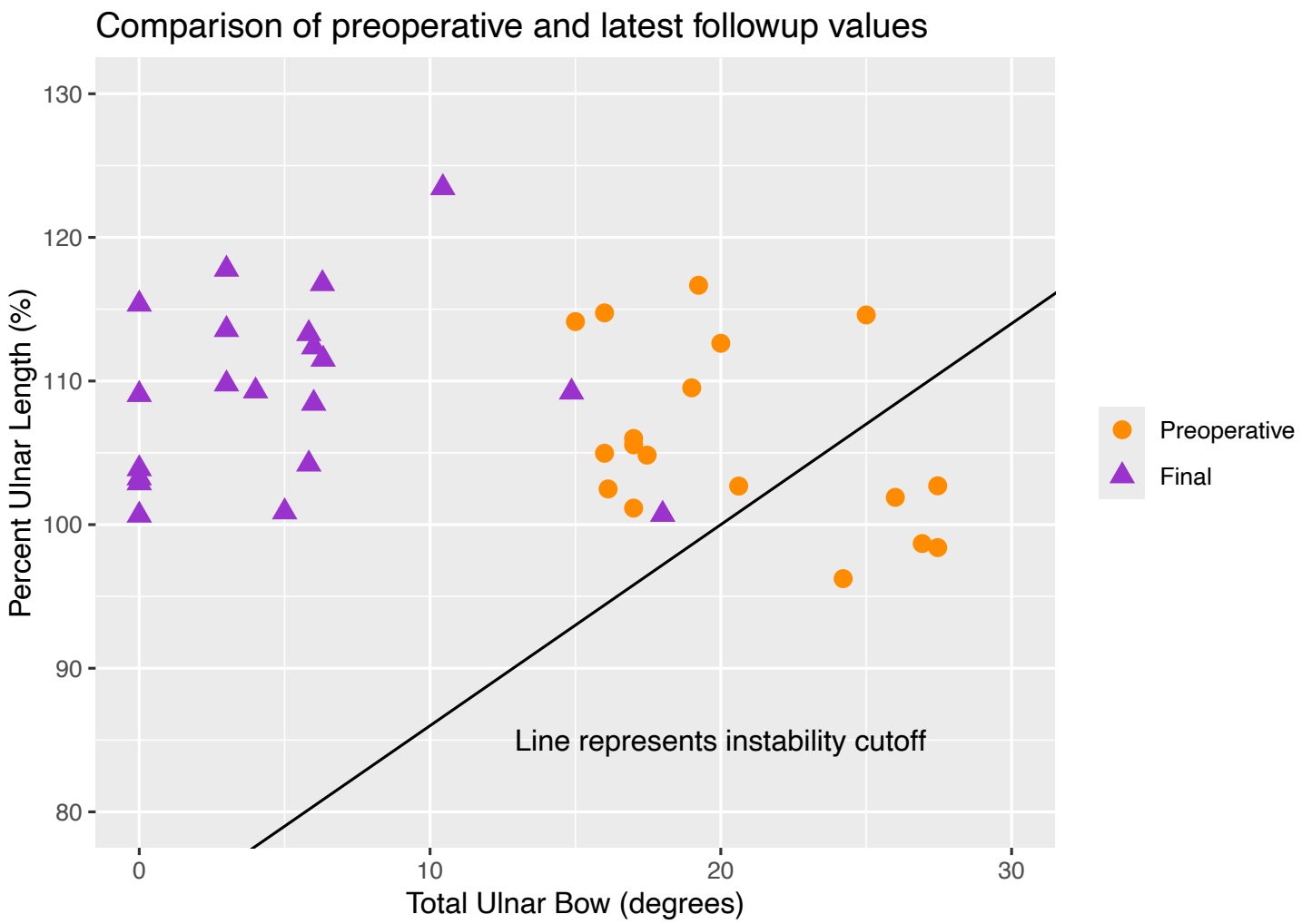
One forearm had a superficial wound infection treated with antibiotics. Five forearms had symptomatic distal ulnar deformity; two have undergone revision surgery. One patient had a non−union requiring repair.

Conclusions: An acute osteotomy of the ulna improves radiographic deformity and reduces the radial head in patients with MHE. The most common complication is the development of a distal ulnar deformity which may be symptomatic and require surgical correction. A small percentage may re-subluxate; continued surveillance is recommended.


Comparison of preoperative and latest followup values
Percent Ulnar Length (%)
130
120
110
100
90
80
0
10
20
30
Total Ulnar Bow (degrees)
Line represents instability cutoff
Preoperative
Final

Pre−Built Computer Assisted External Fixators Compared to Intraoperatively Built Fixators for Deformity Correction and Limb Lengthening, A Retrospective Analysis

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Question: External fixators (EF) have been proven to be an effective treatment for multiple limb deformities. The advent of computer assisted external fixators allowed orthopedic surgeons to treat complex multiplanar deformity. Additionally, it allowed surgeons to pre−build their EFs before surgery. We hypothesize that pre−building EFs using computer software will decrease surgical time while improving their surgical outcome.

Answer: Data concerning patients demographics, indication for surgery, surgical timing, outcomes and complications of 97 computer assisted external fixators were retrospectively collected (48 pre−assembled and 49 intraoperatively assembled).

Results: Average age was 18.7 (18.3 for pre−assembled and 21.4 for intra−operatively assembled) (P>.05). The cohort comprised 60 males and 37 females. All patients met their initial goal of surgery within 4 months of follow up. Operative room (OR) time was significantly less in the pre−assembled group with 106 minutes and 127.5 minutes respectively (P<0.05). Similarly, estimated blood loss was significantly less in the pre−assembled group with 48 versus 99 ml of blood (P<0.05). All patients successfully reached their goal height and/or deformity correction within 4 months of index procedure.

Conclusions: Pre−built frame offers the advantage of decreasing OR time and blood loss during surgery, without affecting the patient's final outcomes.

Health Related Quality of Life of Children with Fibular Hemimelia − The Nine Year Experience of a Regional Children's Hospital

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Question: Does surgical intervention in children with Fibular Hemimelia cause an improvement in their Health Related Quality of Life (HRQL)?

Answer: A prospective longitudinal study collected clinical, functional and HRQL data in children with FH at the senior author€™s institution since 2015. HRQL was assessed using the Pediatric Quality of Life (PedsQL) questionnaire, Pediatric Outcomes Data Collection Instrument (PODCI) and Numeric Pain Rating Scale (NPRS). Linear−mixed model and nonlinear analysis was used to observe the effects of time since presentation, respondent type, and pre vs.post−surgery status on outcome measures.

Results: Of the 38 participants, 30 have had surgery at our institution at the time of analysis. Four out of 38 children had amputations prior to their first visit at our institution. Parents consistently reported lower PedsQL scores than children ($p < 0.05$). Frame removal significantly improved physical and social functioning scores across PedsQL domains ($p < 0.05$). Post−surgery, physical and social functioning decreased, but recovery over time, especially after frame removal, was associated with improved outcomes ($p < 0.05$). NPRS had a median pain score of 0, indicating low levels of reported pain.

Conclusions: Our study highlights a decline in Social Functioning in children with FH post operatively, suggesting surgery may negatively impact social well−being in the early post−operative period. The external fixator frame significantly affects mobility and physical functioning, with lower scores when the frame is on and higher scores when it is removed. Finally, we demonstrate a consistent difference in how parents perceive their child's HRQL versus children's self−perception. The lack of significant changes in overall HRQL scores suggests gaps in understanding how surgery impacts clinical and HRQL outcomes, which could be explored through qualitative research and the use of patient−reported outcome measures specific to lower limb deformity.

Utility Of Long Hip to Ankle Radiographs in Evaluating Limb Length Equality After Prosthesis Fitting for Patients with Lower Extremity Osseointegration

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Question: Since osseointegrated limbs do not change position as socket prostheses do, the normal goal is to provide patients equal limb length to optimize gait and minimize pain related to limb length difference. Typically, a prosthetist evaluates the limb lengths clinically, without access to a long leg radiograph (LLR), which is a common technique for limb lengthening surgeons. The usefulness of the LLR after osseointegrated prosthesis provision has never been evaluated. The aim of this study was to assess the value of LLR to evaluate the accuracy of limb length after the first fitting of the prosthetic leg following osseointegration.

Answer: Medical records at a single institution were reviewed of 124 patients (72 femur and 42 tibia) patients who had unilateral and/or bilateral femur and/or tibial osseointegration and also LLR following prosthesis fitting. Limb length discrepancy (LLD) was measured using the indirect method (difference from a plumb line between the two hip joints). The LLD was tabulated both as the raw amount and also categorized as ≤5 mm, 5–10 mm, 10–20 mm, or ≥20 mm.

Results: The average ILLD was 9.9±8.7 mm (range 3 to 48 mm). Table 1 shows that for both femur and tibia, the most common LLD was ≤5 mm (27 (37.5%) femur, 19 (36.5%) tibia) and the least common was ≥20 mm (11 (15.3%) femur, 3 (5.8%) tibia). There was no significant difference between the accuracy of femur versus tibia patients (≤5 mm 37.5% vs 36.5%, p=.435).

Conclusions: In this cohort, 62.9% of patients exceeded 5 mm and 37.1% exceeded 10 mm of LLD. While it is uncertain how much LLD is impactful to osseointegrated patients, given that the osseointegrated prostheses do not change position the way socket prostheses do, it seems obtaining an LLR after the first prosthesis fitting is useful to achieve limb length equality, which is a standard goal for non–amputated patients. Further research is merited to determine a typical patient–reported detectable difference.

	≤5	5-10	10-20	≥20
All	46 (37.1%)	32 (25.8%)	32 (25.8%)	14 (11.3%)
Femur	27 (37.5%)	18 (25%)	16 (22.2%)	11 (15.3%)
Tibia	19 (36.5%)	14 (26.9%)	16 (30.8%)	3 (5.8%)

Table1: The number of patients LLD with long film after lower extremity OI in all 4 groups.

Socioeconomic Factors Increase Delays to Treatment for Nonunions Without Significantly Compromising Outcomes

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Question: Nonunions are physically and financially burdensome for patients and clinically challenging for orthopedic surgeons. There is evidence that socioeconomic factors are associated with delays to care in general, theoretically increasing the risk of nonunion and malunion treatment failure. The purpose of this study was to determine if the social determinants of health (SDOHs) are associated with delays to care, treatment course complexity, and adverse outcomes among patients with fracture nonunion or malunion.

Answer: We conducted a retrospective analysis of all patients ≥18 years old with fracture nonunion or malunion who underwent surgical correction at a three–hospital health system in an underserved urban community between November 2015 and June 2024. SDOHs considered include race, ethnicity, spoken language, insurance, Distressed Community Index, and prior treatment location (domestic vs. abroad). Outcomes assessed include time from initial injury to corrective operation, incidence of postoperative complications within 90 days, and bone union within 12 months. For patients achieving union, additional outcomes include number of operations required, total hospital length of stay for operations, unexpected reoperations, and time to union. P–values were obtained from Wilcoxon rank–sum, Kruskal–Wallis, or Fisher's exact tests as appropriate.

Results: Of 246 patients, other and black race ($p = 0.011$), non–English language ($p = 0.001$), and initial treatment abroad ($p = 0.001$) were significantly associated with longer time to treatment from initial injury. Of 212 patients with ≥90 days of follow–up, the selected SDOHs were not significantly associated with complications or rehospitalizations. Of 162 patients with ≥12 months of follow–up, the selected SDOHs were not associated with achieving union within 12 months of operation. Of 136 patients achieving union, those initially treated abroad experienced significantly longer times to union ($p = 0.020$). Private insurance was associated with more corrective operations ($p = 0.043$), and public insurance was associated with achieving union with the original surgical plan ($p = 0.032$). The selected SDOHs were not significantly associated with total length of stay or unexpected reoperation.

Conclusions: SDOHs are associated with delays to nonunion or malunion care. Patients initially treated abroad experience longer times to union following surgery. The lack of association between SDOHs and complication and reoperation rates suggest institutional success in addressing these disparities, suggesting that institutions serving diverse communities are positioned to bridge prevalent disparities in chronic fracture management.

Unexpected Positive Intraoperative Cultures (UPIC) at Index Press–fit Osseointegration Do Not Lead to Postoperative Infection Events

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Question: Although diagnosis remains ambiguous, infection remains the most commonly reported adverse event following transcutaneous osseointegration. The assumption is that the majority of contamination originates from the transcutaneous portal, but pre–existing intramedullary or intraoperative contamination can represent another potential source. However, only one study has evaluated this potential impact. The current study builds upon the previous publication, evaluating the clinical impact of unexpected positive intraoperative cultures (UPIC) on postoperative infection rates after osseointegration.

Answer: Medical records were retrospectively reviewed for 17 patients with UPIC and 111 patients with negative intraoperative cultures (NIC), all of whom had at least one year of post–osseointegration follow–up. All patients received routine immediate preoperative and postoperative antibiotic prophylaxis for 24 hours; patients with UPIC (determined from intraoperative cultures from the intramedullary canal immediately after exposure) were given additional targeted antibiotics based on culture sensitivities. The main outcome measure was postoperative infection intervention, which was graded as 0) none, 1) oral antibiotics prescribed for clinical reasons unrelated to culture results at the initial surgery, 2) operative debridement with implant retention, or 3) implant removal.

Results: Table 1 shows the UPIC vs. NIC rate of interventions to manage post–operative infection: Grade 0, 47.1 % (8/17) vs. 37.2 % (42/113) (Fisher's p = 0.437); Grade 1, 35.3 % (6/17) vs. 50.4 % (57/113) (p = 0.303); Grade 2, 17.6 % (3/17) vs. 9.7 % (11/113) (p = 0.394); Grade 3, 0 % (0/17) vs. 0.9 % (1/113) (p = 1.000). No differences were statistically significant. No UPIC patients who received the therapeutic antibiotic course developed antibiotic–related adverse sequelae.

Conclusions: At the current volume, there is no recognized impact of UPIC on postoperative infection intervention, when the UPIC patients are provided a therapeutic course of postoperative antibiotics. Targeted antibiotic therapy was not associated with adverse outcomes. However, the clinical benefit of providing versus not providing directed antibiotic therapy for UPIC remains unknown, as no UPIC patients did not receive a therapeutic course.

Understanding the Experiences of Families and the Role of Social Stigma in Children with Lower Limb Differences: A Qualitative Study

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Question: What are the unique experiences of families with children with lower limb differences, particularly in regards to navigating health education, treatment, the healthcare system, and societal barriers and stigma?

Answer: Parents of children with lower limb differences were interviewed for this qualitative research study. Interviews with open–ended questions were conducted and transcribed. Each interview was coded by two independent reviewers on Dedoose, a qualitative coding platform. Following a thematic analysis approach, categorical groupings and emerging patterns were identified.

Results: 14 parents of 11 children were interviewed. 11 are mothers and 3 are fathers. Demographic data of the parents showed that 8 identified as Caucasian, 3 as African American, and 3 as Asian. The average age of children was 11.4 ï‚± 4.05 years (range: 6–18). 7 children identified as female, 6 as male, and 1 as nonbinary. Lower limb differences were categorized as congenital (n=5), developmental (n=5), and acquired (n=1). Thematic analysis of the interviews revealed the following as prevalent emerging themes:

(1) Impact on Day–to–Day Life:
Parents described challenges in helping their children transition back to their daily routines, especially returning to sports like soccer and swimming. Some also noted that their children experienced social difficulties, including losing friends due to misconceptions about their abilities.

(2) Support from Community:
Despite initial difficulties in responding to questions from others, most parents felt that these inquires stemmed from general curiosity rather than judgment. Many also noted that teachers provided strong support in helping their children adjust in the school setting.

(3) Trust in Medical Team:
Although parents described the initial process of navigating care as overwhelming, all expressed immense satisfaction with the medical team at their current institution. Many emphasized their appreciation for the team's commitment to shared decision–making when considering treatment options for their child.

Conclusions: This study has provided initial insights into the role social stigma plays in parental decisions while navigating care for their children with lower limb differences. Further contextualizing the psychosocial experience of patients and their families may lead to improved treatment adherence and better outcomes. Next steps include conducting more interviews including parents of children with different ethnicities, an in–depth analysis of the interviews and quotes, interviewing the patients, and ultimately expanding the study to other countries to identify how local resources and social factors shape experiences across diverse settings.

Reference Values for Pediatric Coronal Lower Extremity Alignment using EOS Standing Radiographs

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Question: There is a lack of data on normal reference values for standing lower extremity alignment in the pediatric population in the United States. This study aims to outline normal reference values for coronal lower extremity alignment parameters in the pediatric population by age group using EOS standing radiographs.

Answer: We measured coronal plane lower extremity alignment parameters in the pediatric population using EOS standing radiographs. For each age group from 4 to 16 years, we measured radiographic parameters for at least 10 lower extremities without pathology or surgical history, and we collected the following information from each radiograph: mechanical axis deviation (MAD), mechanical lateral distal femoral angle (mLDFA), medial proximal tibial angle (MPTA), and lateral distal tibial angle (LDTA). We calculated the mean and standard deviation of each parameter in each age group.

Results: In this study, 134 EOS films were analyzed for coronal lower extremity alignment in the pediatric population age 4 to 16 years. Our results displayed in Table 1 show that some variation exists in mechanical axis deviation as the pediatric population ages, however valgus alignment predominates, with MAD range of –1.7mm to –9mm valgus alignment during childhood. Table 1 also demonstrates that the measured coronal alignment angular values in the pediatric population were within reference range of adult–specific values throughout childhood and into adolescence.

Conclusions: EOS standing films can be utilized to measure coronal lower extremity alignment in the pediatric population. It may be useful to use pediatric–specific reference values when evaluating mechanical axis deviation, however it may be reasonable to use adult–specific reference values for coronal angular measurements in the pediatric population. Future studies should seek to investigate gender differences in alignment within in each age group as well as sagittal alignment analysis using EOS films.

Table 1. Coronal plane lower extremity measurements in the pediatric population using EOS standing films

		Coronal Plane Measurements			
Age	n	MAD (mm)	mLDFA	MPTA	LDTA
4	11	-4.7±6.1	87.4±3.1	89.8±1.4	90.1±2
5	10	-2.6±3.2	86.8±1.8	89±1.6	88.8±1.4
6	12	-3±4.4	87.5±2	89.2±1.8	87.6±2.3
7	10	-5.6±3.4	86.3±2.4	89.1±1.5	89.4±2.8
8	10	-7.3±3.8	86±1.4	88±2.1	86.3±4.1
9	10	-3.4±3.4	86.8±2.5	88.7±2.2	88.5±2.7
10	10	-7.4±3	85.1±1.9	88.2±2.1	87.8±3.8
11	10	-4.4±2.4	85.6±1.5	87.8±1.7	89.8±2.6
12	10	-9±5.7	84.5±2.1	87.8±1.5	89±2.7
13	10	-5.8±4.2	85±1.8	88.7±1.1	88.7±1.7
14	10	-4.9±4	86.4±1.2	87.3±1.6	89.6±3.1
15	10	-1.7±5.2	86.1±1.4	87.9±1.5	89.4±2
16	11	-5.2±7.5	85.3±3.4	88.2±2.3	89.5±3

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Do Social Determinants of Health Impact the Management and Outcomes of Pediatric Blount's Disease Correction with External Fixation?

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Question: The goal of this study was to determine the relationship between degree of social deprivation and the severity/outcomes of Blount's disease correction with external fixation.

Answer: A retrospective cohort study was conducted of patients ≤ 21 years of age with a diagnosis of Blount's Disease who underwent external fixator correction at a single, large tertiary care pediatric hospital from 2012−2024. Demographic, clinical, and radiographic characteristics including mechanical axis deviation (MAD) were collected. Neighborhood conditions were categorized using the Child Opportunity Index (COI) scores. COI is classified in two different ways: COI quintiles ranging from "very low" to "very high" and by a nationally normed COI numeric score ranging from 0−100. Clinical and radiographic parameters were compared across COI categories and insurance types.

Results: A total of 41 patients (10 female, 31 male) with a mean age of 13.8 ± 2.8 years met the inclusion criteria. Of this cohort, 16 (39%) patients were white, 21 (51.2%) were African American, and 4 (9.7%) were a different race. 35 (85.4%) patients underwent unilateral correction, while 6 (14.6%) had bilateral correction. 36 patients had COI information available, and all patients had insurance information.

Pre−operatively, the average MAD for patients with an angular deformity was 74.5 ± 34.5 mm [range: 12.8−172.1 mm]. There was a significant negative correlation in the degree of pre−operative angular deformity quantified by MAD and COI (p=0.009) suggesting that patients residing in the lowest opportunity neighborhoods presented with a greater deformity.

There were no significant differences in the average number of days in the external fixator (142.8 ± 63.6 days), number of pin site infections (0.7 ± 1.1), or number of no−show appointments (0.4 ± 1.0) and national COI level (p=0.243, 0.910, 0.086 respectively). Furthermore, we did not appreciate a significant difference in post−operative outcomes and COI category or insurance type (Tables 2 and 3).

Conclusions: Neighborhood resources can be associated with delays in presentation, specifically for patients with Blount's Disease, hence increased degree of deformity severity. We did not appreciate statistical significance in COI and external fixator outcomes, although this was likely due to small sample size. Identification of care timelines and postoperative outcomes facilitate future research efforts to examine underlying barriers to poor outcomes and post−operative difficulties with external fixator care compliance.

Table 1: Limb deformity parameters based on national COI

	Correlation Coefficient	P-value[1]
Initial MAD	-0.431	0.009***
Final MAD	-0.308	0.134
Time in Ex Fix	-0.200	0.243
Number Pin Site Infections	-0.020	0.910
Number of No-Show Appointments	-0.290	0.086

[1]Spearman's correlation; ***P value < 0.05 was considered significant

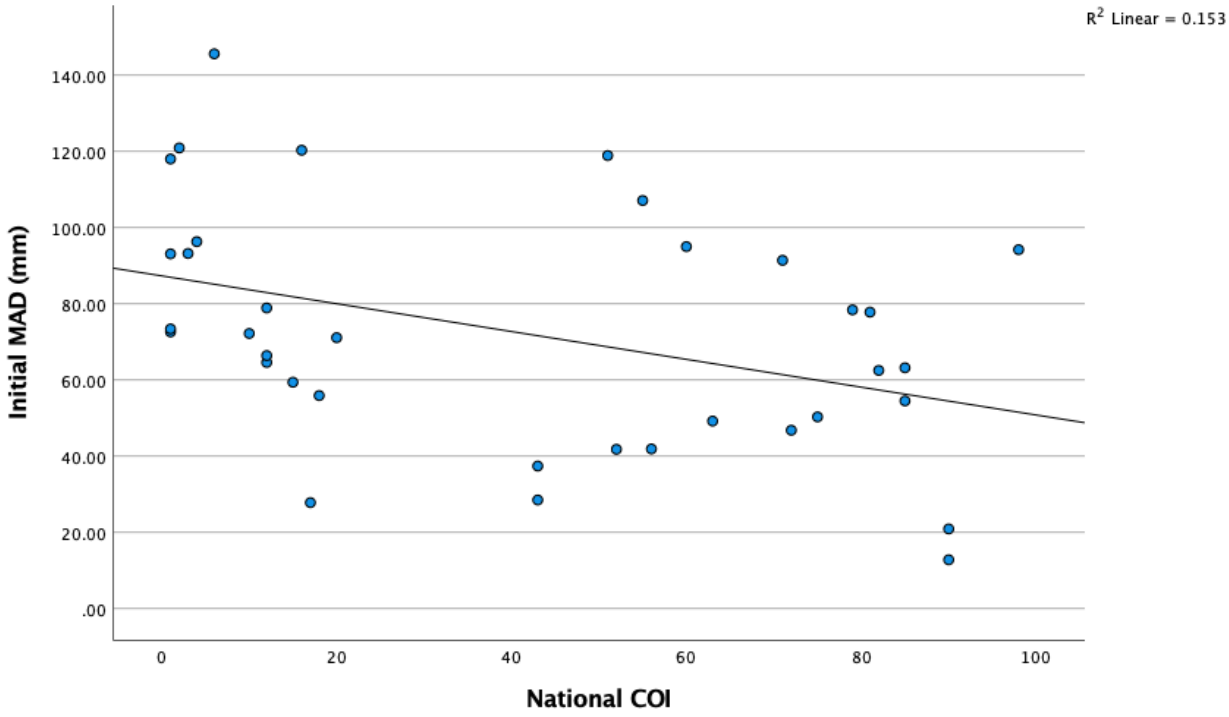

Figure 1: Correlation between MAD at presentation and national COI.

Table 2: Characteristics by nationally normed COI level

	COI National n (%)					P-value[1]
	Very Low	**Low**	**Moderate**	**High**	**Very High**	
Sex						0.905
Female	5 (13.9)	0 (0)	2 (5.6)	2 (5.6)	1 (2.8)	
Male	12 (33.3)	0 (0)	5 (13.9)	3 (8.3)	6 (16.7)	
Laterality						0.299
Left	10 (27.8)	0 (0)	5 (13.9)	4 (11.1)	2 (5.6)	
Right	7 (19.4)	0 (0)	2 (5.6)	1 (2.8)	5 (13.9)	
Complications						0.351
Yes	11 (30.6)	0 (0)	3 (8.3)	1 (2.8)	4 (11.1)	
No	6 (16.7)	0 (0)	4 (11.1)	4 (11.1)	3 (8.3)	
Pin Site Infections						0.729
Yes	8 (22.2)	0 (0)	2 (5.6)	1 (2.8)	3 (8.3)	
No	9 (25.0)	0 (0)	5 (13.9)	4 (11.1)	4 (11.1)	
Return to OR						0.999
Yes	1 (2.8)	0 (0)	0 (0)	0 (0)	0 (0)	
No	16 (44.4)	0 (0)	7 (19.4)	5 (13.9)	7 (19.4)	
Struts Incorrect						0.733
Yes	8 (22.2)	0 (0)	2 (5.6)	1 (2.8)	2 (5.6)	
No	9 (25.0)	0 (0)	5 (13.9)	4 (11.1)	5 (13.9)	
Residual Program Run						0.504
Yes	6 (16.7)	0 (0)	4 (11.1)	1 (2.8)	4 (11.1)	
No	11 (30.6)	0 (0)	3 (8.3)	4 (11.1)	3 (8.3)	
Antibiotics						0.729
Yes	8 (22.2)	0 (0)	2 (5.6)	1 (2.8)	3 (8.3)	
No	9 (25.0)	0 (0)	5 (13.9)	4 (11.1)	4 (11.1)	
PT						0.833
Yes	11 (30.6)	0 (0)	5 (13.9)	3 (8.3)	6 (16.7)	
No	6 (16.7)	0 (0)	2 (5.6)	2 (5.6)	1 (2.8)	
Inpatient Stay for Rehab/Difficulty with Turns						0.101
Yes	0 (0)	0 (0)	1 (2.8)	1 (2.8)	2 (5.6)	
No	17 (47.2)	0 (0)	6 (16.7)	5 (13.9)	5 (13.9)	

[1]Fisher's Exact Test; ***P value < 0.05 was considered significant

Table 3: Characteristics by insurance status

	Insurance Type		P-value[1]
	Private	**Public**	
Sex			0.081
Female	2 (4.9)	8 (19.5)	
Male	16 (39.0)	15 (36.6)	
Laterality			0.600
Left	10 (24.4)	13 (31.7)	
Right	8 (19.5)	10 (24.4)	
Complications			0.540
Yes	10 (24.4)	12 (29.3)	
No	8 (19.5)	11 (26.8)	
Pin Site Infections			0.621
Yes	7 (17.1)	9 (22.0)	
No	11 (26.8)	14 (34.1)	
Return to OR			0.187
Yes	2 (4.9)	0 (0)	
No	16 (39.0)	23 (56.1)	
Struts Incorrect			0.406
Yes	7 (17.1)	7 (17.1)	
No	11 (26.8)	16 (39.0)	
Residual Program Run			0.479
Yes	6 (14.6)	9 (22.0)	
No	12 (29.3)	14 (34.1)	
Antibiotics			0.621
Yes	7 (17.1)	9 (22.0)	
No	11 (26.8)	14 (34.1)	
PT			0.594
Yes	12 (29.3)	15 (36.6)	
No	6 (14.6)	8 (19.5)	
Inpatient Stay for Rehab/Difficulty with Turns			0.615
Yes	1 (2.4)	2 (4.9)	
No	17 (41.5)	21 (51.2)	
[1]Fisher's Exact Test; ***P value < 0.05 was considered significant			

Employing a Computerized Circular External Fixator to Correct Post−Operative Valgus Collapse and Lateral Knee Instability following the Comminuted Tibial Plateau Fracture

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Question: Valgus collapse and lateral joint instability are both common and feared complications following comminuted tibial plateau fractures, conferring significant loss of form and function and eventual definitive treatment with arthroplasty. Many treatment modalities have been assessed for acute deformity correction but often yield unsatisfactory results. This study aims to evaluate the treatment of such deformities using a computerized hexapod frame.

Answer: A single−center retrospective chart review of valgus collapse following comminuted tibial plateau fractures treated with computerized hexapod frame application was performed. Radiographic parameters included mechanical axis deviation (MAD), angle of valgus, mechanical lateral distal femoral angle (mLDFA), mechanical medial proximal tibial angle (mMPTA), time to radiographic union, and degree of most treatment osteoarthritic change. Functional parameters include the degree of lateral joint laxity, range of motion, and verbalized pain scores.

Results: A total of four patients were identified with valgus collapse and malunion following tibial plateau fracture fixation. Initial injury classification included Schatzker type VI (2), Schatzker type V (1), and Schatzker type II (1). The mean age at application was 60.25 years (49−68) with a mean latency from injury to reconstruction of 316.5 days (112−559). Mean time to device removal was 159.25 days (130−184) and mean time to union was 175.25 days (143−202). All four subjects (100%) achieved a neutral mechanical axis and reported significant improvement of lateral joint laxity and instability on valgus stress. All four subjects reported significant improvement of pain from 4.5(1−7) pre−operatively to 1(0−2) postoperatively. All four subjects (100%) regained full range of motion despite two subjects (50%) developing post−reconstructive flexion contracture of mean 7.5 degrees (5−10) treated with extensive physical therapy.

Conclusions: Osteotomy at the lateral tibial plateau and application of a computerized external fixator for gradual correction of valgus collapse following comminuted tibial plateau fractures allows for precise restoration of mechanical alignment and rescue of lateral knee laxity and instability. Soft tissue management and physical therapy remained key in preventing flexion contracture during and after reconstruction, which resulted in significant improvements in form, function, and stability.

Postoperative Non−Invasive Blood Pressure Monitoring for Patients with Osteogenesis Imperfecta is Safe and Feasible

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Question: Osteogenesis imperfecta (OI) is a genetic disorder related to inadequately or improperly produced Type I collagen. OI patients require multiple surgeries with significant blood loss and pain medications associated with hypotension. Their fragile bones and bowing deformities introduce challenges and fracture risk with a non−invasive blood pressure (BP) cuff. Scant literature exists regarding postoperative non−invasive BP monitoring. Our purpose was to design such a protocol and demonstrate safe implementation to €œbust the myth€ this is not feasible.

Answer: OI patients undergoing extremity or spine procedures were prospectively enrolled. Inclusion criteria included approval by an orthopaedic surgeon specialized in OI care, ages 1−35 years and postoperative admittance to non−ICU settings. As hypotension was the primary concern and to minimize fracture risk, low maximum inflating pressures were used: 100 mmHg − neonatal/infant/pediatric sized cuffs; 130 mm Hg − adult cuffs. Blood pressures were taken per standard institutional postoperative care: no more than every 4 hours for the first 24 hours; every 8 hours or less thereafter. BP was measured manually by RNs with inspection of the extremity and inquiry regarding signs of fracture before and after each measurement. If a blood pressure was not feasible, RN attempted same protocol on alternate side if feasible.

Results: Fifty−five participants enrolled. Nine did not participate due to changes in the interval between consent and study procedure onset; five changed their minds, three subsequently met exclusion criteria, one had surgery when the study was temporarily paused. Of the remaining 46 participants: mean age was 12 years, 24 females, 22 males. Twenty−six underwent extremity and 30 spine surgery. Types of OI included: Type I−4, Type III−19, Type IV−19, Type XI−2, Cole−Carpenter−2. Patients underwent average of 11 BP measurements each with no sequelae. No fractures occurred. Two participants withdrew prior to study completion, one after four BP readings due to discomfort with cuff, one after five readings as parent perceived BPs no longer necessary.

Conclusions: Non−invasive BP measurements may be safely obtained in the postoperative period for OI patients. We recommend manual cuff use and monitoring for signs or symptoms of fracture. This practice−changing protocol may help OI patients avoid postoperative use of arterial lines and associated ICU admission. This protocol is applicable to other hospitals and allows OI patients to have non−invasive BP monitoring previously avoided. As adults with OI live longer, this protocol will help facilitate preventative care for cardiovascular disease.

Use of Reamer–Irrigator–Aspirator (RIA) in the Treatment of Septic Nonunion Associated with Less Postoperative Infections

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Questions: The purpose of this study was to assess rates of union and complications associated with irrigation and debridement (I&D) of suspected septic nonunion of the leg with RIA versus without.

Answer: We conducted a retrospective cohort study of all adult patients with fracture nonunion or malunion of any bone who underwent surgical correction at a three–hospital health system between November 2015 and June 2024. 54 patients who underwent I&D for suspected septic nonunion of the leg were identified; RIA was used in 59.3% (n = 32) of I&D cases. Outcomes assessed included if union was achieved within 12 months of surgery and the incidence of having 1 or more complications within 90 days, as well as the specific incidences of postoperative anemia, infection, vascular complications [including myocardial infarction (MI), venous thromboembolism (VTE), stroke, and transient ischemic attack (TIA)], and rehospitalization for complication. Patients with less than 12 months and 90 days of follow–up were excluded from analysis, respectively. Fisher€™s exact tests were used to assess statistical significance.

Results: Of 48 patients with 90 days of follow–up, patients with femur or tibia nonunions treated with I&D with RIA had significantly fewer postoperative infections compared to I&D without RIA ($p = 0.049$). The incidence of having 1 or more complications ($p = 0.769$), postoperative anemia ($p = 1.000$), vascular complications ($p = 1.000$), and rehospitalization for complication ($p = 1.000$) were comparable between groups who underwent I&D with and without RIA. Of 41 patients with 12 months of follow–up, there was no statistically significant difference in rates of achieving union within 12 months of operation for both groups ($p = 0.277$). No fatalities were reported in either group.

Conclusions: Use of RIA in I&D of septic nonunion of the leg is significantly associated with fewer postoperative infections than I&D without RIA. This data suggests that RIA is a safe device associated with no added complication risk that can be used to successfully treat suspected septic nonunion of the femur or tibia.

Guided Growth Treatment for Leg Length Discrepancy and Angular Deformities

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Question: What is the rate of correction, rate of need to return to the operating room and rate of complications during the guided growth treatment for lower limb deformity correction and limb length discrepancy?

Answer: This is a retrospective study of patients who were managed with GGT since 2012 until 2024 at a single center. We included all patient who received this treatment to correct coronal plane deformities in the distal femur and/or the proximal tibia. Data was collected from the medical and radiographic records and then stratified based on deformity type and location. The endpoint of this study was achievement of treatment goal (typically mechanical axis in zone 1 for children with AD and limb length difference less than 1cm in children with LLD.

Results: The total number of patients was 131 (69 boys, 53%), mean age at the time of surgery was 11.7 ± 2.6 years. The most common etiology was developmental, 68 (52%). The indication for surgery was limb length discrepancy in 27 patients, in these instrumented guided growth included (11 tension band plates, 1 staple and 3 transphyseal screws) while irreversible, non–instrumented method was used in 12. The rate of failure to reach limb length equalization was high (22/27), while 4 patient achieved limb length difference within 1cm and one patient had an over correction within 1 cm. None of these patients required further limb length equalization procedure. However, some patients were still under observation and had not reached skeletal maturity at the latest follow up.
In patients with angular deformity, 27 had varus deformity, 75 had valgus and 2 had a windswept deformity. Bilateral growth modulation was done in 73/106 (69%) patients. Overall, the number of limbs with angular deformity was 174, 121 (70%) achieved full correction, 2 had an overcorrection and 51 did not reach full correction. However, some patients were still under observation and had not reached skeletal maturity. Based on the most recent follow–up, limbs that underwent both distal femur and proximal tibia guided growth (rather than a single bone), while demonstrating improved alignment more often failed to achieve mechanical axis alignment through zone 1 ($p<0.0001$). We also noted a higher rate of complete healing in patients with genu valgum deformity (<0.0001).
Guided growth instrumentation removal was performed in 78/131 (59%) patients. Overall, the rate of complications was 13/131 (1%). Based on Dindo–Clavien classification, 5 patients had grade 2 complication because of superficial wound infection and dehiscence that required oral antibiotics. Eight patients had grade 3 complication that required return to the OR (5 patient for unplanned hardware removal for pain, prominence or overcorrection and 3 needed surgeries for further guided growth treatment).

Conclusions: While guided growth treatment for LLD and AD is effective in improving alignment and limb length. Patients require careful selection and monitoring to avoid overcorrection and to allow enough time to intervene to achieve the desired correction.

A New Percutaneous Osteotomy for Better Regenerate

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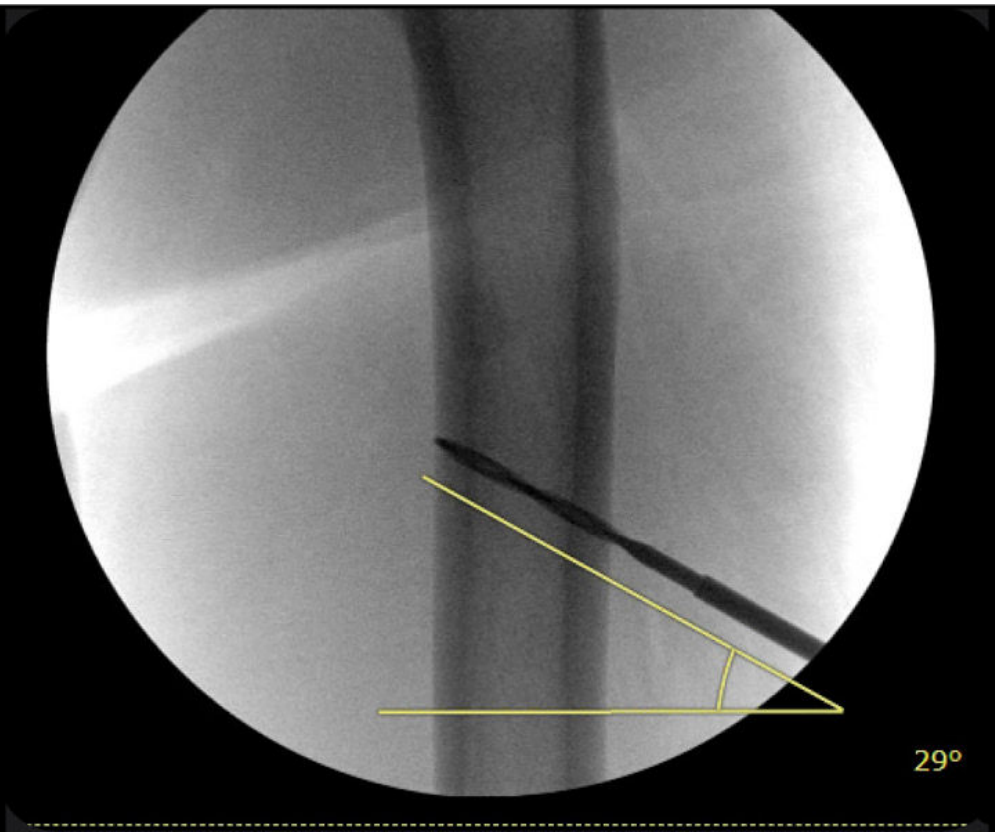
Question: How can we get better regenerate? Distraction osteogenesis is a used for both bone lengthening and bone transport in complex deformity and bone defect cases. Traditional techniques involve creating a transverse osteotomy that is perpendicular to the long axis of the bone. The geometry of this transverse osteotomy minimizes bony surface area for regenerate potential.

Answer: The purpose of this presentation is to demonstrate a new technique to perform a controlled oblique osteotomy to increase cross–sectional area of the osteotomy through a percutaneous procedure.

Results: In a cylindrical bone model, a 45° osteotomy increases cross–sectional area by 41%. This has clinical implications for more robust regenerate formation and faster lengthening and transport times.

Conclusions: This novel percutaneous technique allowed for creation of an oblique osteotomy to increase cross–sectional area that increases volume of bony regenerate and decreases distraction time during long bone lengthening and transport.



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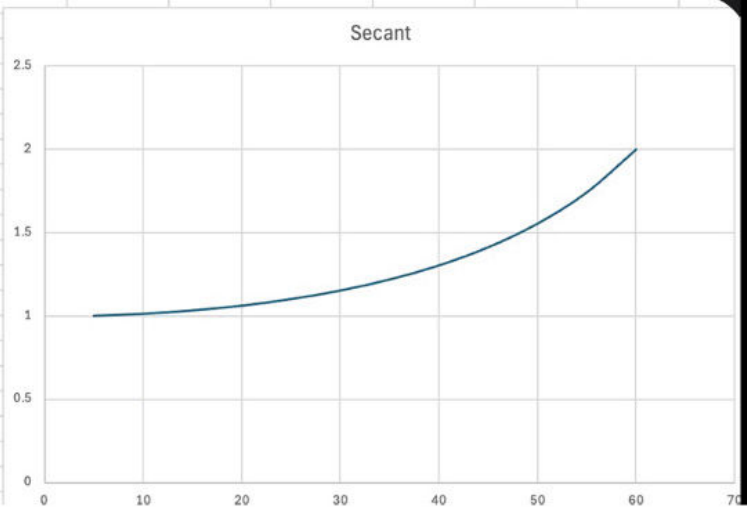

Press–fit Osseointegration for Tibial Amputees with Ertl Crossunion

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Question: Press–fit transtibial osseointegration of the tibia enables a direct transcutaneous skeletal connection between a prosthetic leg and the residual tibia. A skeletally anchored prosthesis typically improves mobility, balance, and proprioception to amputees, eliminating problems associated with socket mounted prostheses such as skin irritation, poor fit, and pain. The Ertl technique for transtibial amputation is relatively frequently performed, and features creation of a tibiofibular bone bridge to potentially provide additional stability. It has never been studied to what extent this bony bridge impacts osseointegration planning, technique, or outcomes. The purpose of this research is to evaluate the clinical and patient reported outcomes of transtibial osseointegration following existing Ertl amputations.

Answer: Retrospective review was performed of all patients who underwent press–fit tibial osseointegration at our center for existing Ertl and non–Ertl transtibial amputation. The primary outcome was adverse events prompting additional surgery. Additional outcomes were changes in mobility: timed up and go (TUG), 2 minute walk test (2MWT), 6 minute walk test (6MWT), and patient–reported quality of life surveys (LD–SRS and PROMIS) outcome scores.

Results: Nine patients with ten Ertl amputations were included. Their outcomes were compared to 85 limbs undergoing tibial osseointegration after non–Ertl amputations. Although all Ertl patients€™ osseointegration required revising the amputation to above the cross–union, there were no additional planning or technique challenges. No instances of implant loosening, or periprosthetic fracture occurred or breakage occurred, nor did any patient develop a deep infection prompting additional surgery. Both the Ertl and Not Ertl cohorts had statistically significant improvements in most mobility and survey categories. Comparing Ertl vs Not Ertl, only the Timed Up and Go revealed a clinically significant difference.

Conclusions: The presence of an Ertl style amputation crossunion does pose a detectable planning, technique, or recovery risk versus non–Ertl patients, nor is there a recognized difference in mobility and quality of life outcomes. Surgeons may want to plan revision amputation with implant insertion proximal to the crossunion when possible, rather than placing the implant through the transverse crossunion, to provide the most familiar technical experience.

Quantitative Assessment of Regenerate Bone Maturation Using the Pixel Value Ratio Following Distraction Osteogenesis: A Scoping Review

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Question: Methods to objectively assess the maturation of the regenerate bone formed during distraction osteogenesis, such as quantitative Computerized Tomography (qCT) scans or DEXA scans, are expensive and impractical. This has led to the search for more affordable and practical solutions. The pixel value ratio (PVR), derived from digital radiological images, has demonstrated a good correlation and reliability in providing an objective assessment of the mineralization state of the regenerate. However, the threshold value for safe full−weight bearing using the PVR remains unknown. This scoping review, based on a systematic literature search, aims to identify studies that have used the PVR to assess mineralization of the regenerate following distraction osteogenesis for limb lengthening in humans, describe and review the methods of application of the PVR in assessing bone mineralization, and determine the PVR at the time of full unassisted weight−bearing ambulation, hardware removal, and the incidence of complications related to the timing of full weight−bearing ambulation.

Answer: The findings of this scoping review are reported according to the Preferred Reporting Items for Systematic Reviews and Meta−Analyses extension for Scoping Reviews (PRISMA−ScR). Using the PCC (Participants, concept, and context) framework, human clinical studies evaluating the mineralization of the regenerate bone using the PVR, either as a stand−alone assessment tool or as an adjunct to other objective measures of mineralization, published in English, were reviewed. We carried out a systematic search of seven databases using relevant keywords. An experienced librarian was involved in creating the search string. We managed our data using an EndNote library and the Covidence software tool. Two independent reviewers conducted title and abstract screening, as well as full−text screening, with disagreements resolved by consensus. Data from the included full texts were extracted using a data extraction tool, with the results summarized and presented in a narrative format.

Results: Two hundred and fifteen studies were found using our search strategy. One hundred and twenty−three duplicates were removed. Sixty−three studies were deemed irrelevant after screening the titles and abstracts. Twenty−two of the twenty−nine full texts screened were eligible for inclusion in the review. This included 21 retrospective and one prospective randomized controlled trial. (See Figure) Fourteen studies involved the assessment of the regenerate following extramedullary lengthening, while six involved intramedullary bone lengthening, and two combined both intramedullary and extramedullary lengthening. The number of included patients in the studies ranged from 12−125. Ten studies assessed the tibia, four studies evaluated the femur, while seven studies combined assessment of the tibia and femur. One study assessed the regenerate bone in the humerus and femur. Sixteen studies calculated the PVR by dividing the pixel value of the regenerate bone by the average pixel value of the proximal and distal adjacent cortex. Only 8 of the 22 studies reported the PVR at the time of full

Quantitative Assessment of Regenerate Bone Maturation Using the Pixel Value Ratio Following Distraction Osteogenesis: A Scoping Review *continued*

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weight−bearing ambulation. In 5 of the studies, this ranged from 0.85 to 0.94. The PVR at the time of hardware removal was not determined in 19 studies. The PVR was used as the sole method of assessing the regenerate bone in only three studies. Only two studies discussed complications related to the regenerate bone.

Conclusions: The PVR has been used thus far, largely as an adjunct to assessing consolidation and mineralization of the regenerate during distraction osteogenesis. There is no consensus on the best modality for calculating the PVR, and to date, its application in determining the time to commence full weight−bearing ambulation or hardware removal following distraction osteogenesis has been limited.

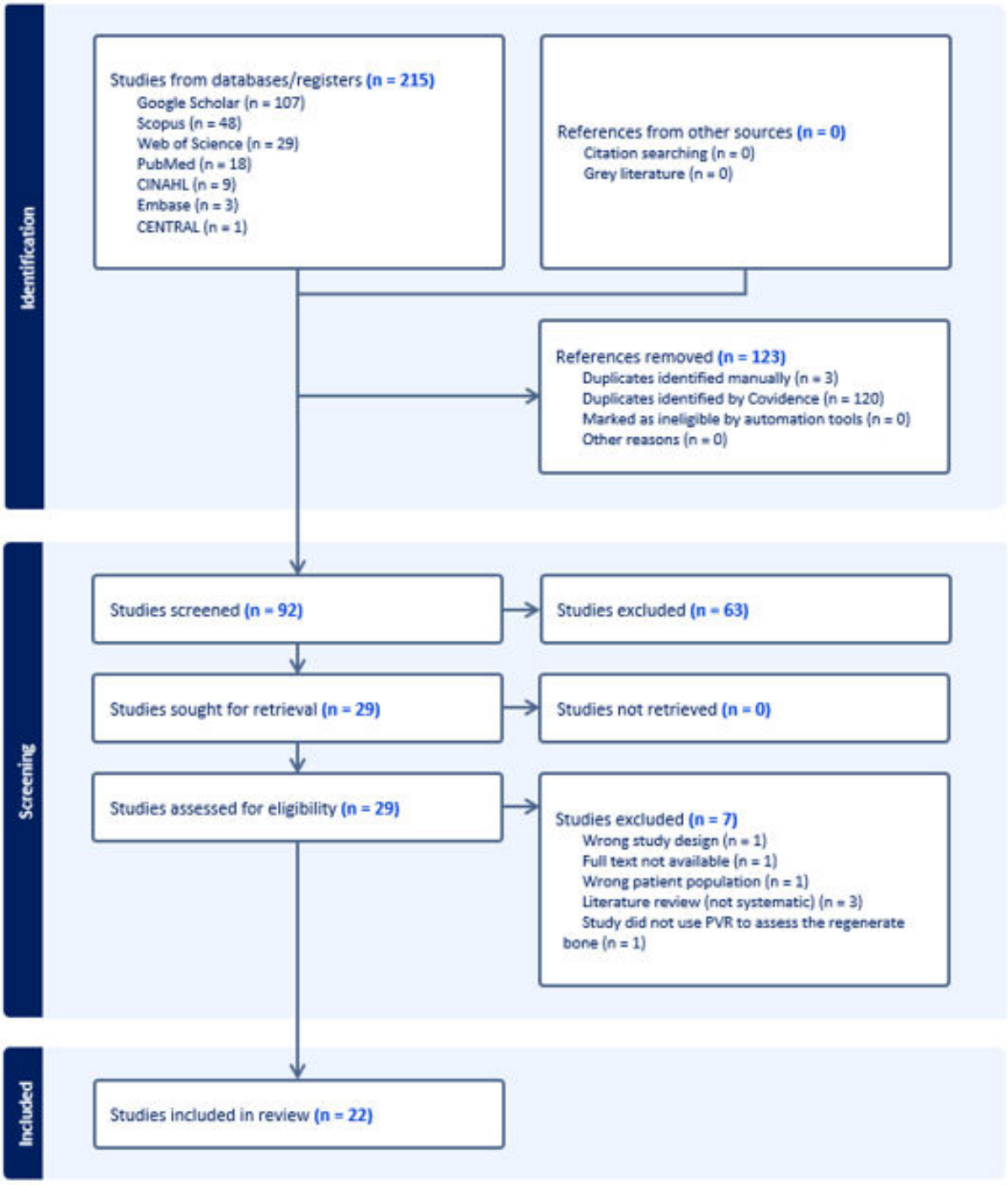

Figure. PRISMA Flowchart illustrating search results and the study selection process.

Measuring What Children Like or Dislike about Their Prosthesis: Development of A New PROM to Measure Children's Satisfaction with Their Prosthesis

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Question: Children with limb deficiencies face unique challenges in participating in day−to−day and recreational activities. Satisfaction with their prosthesis plays a critical role in mobility, prosthesis use, and overall adherence to treatment. However, dissatisfaction rates are high − with 40−60% of patients reporting dissatisfaction, and rejection rates up to 31% in lower limb and 50% non−use in upper limb prostheses. Despite this, there is currently no validated patient−reported outcome measure (PROM) developed with direct input from children to assess satisfaction with their prosthesis. Our study aims to address this question: How can we develop a validated, patient−reported outcome measure (PROM) that accurately captures satisfaction with prostheses from the perspective of children with amputations and limb differences?

Answer: We are conducting a prospective, multiphase, mixed−methods study to develop a child−centered PROM. In Phase 1 (currently in progress), we are conducting cognitive debriefing interviews with children aged 8−18 years who use upper or lower limb prostheses. Participants were recruited through pediatric limb difference clinics, prosthetic clinics across Canada and US, War Amps newsletters, and social media platforms. Interview data include demographic and clinical information, such as age, gender, diagnosis, type of amputation, type of prosthesis, treatment history, and current stage of treatment. Feedback from these interviews is being used to develop the new PROM.

Results: To date, seven interviews have been completed with children using lower limb prostheses (5 boys, 2 girls; mean age 15.62 years, range 8−17 years). Recruitment is ongoing. Preliminary analysis has identified new themes relevant to prosthesis satisfaction, including the importance of flexibility across different situations, experience with liners and socks, and the look and durability of the prosthetic foot. Minor revisions to the PROM have been made based on this feedback. Once data saturation is reached, expert feedback from clinicians (orthopaedic surgeons, prosthetists, nurses, physiotherapists, occupational therapists, and psychologists) will be used to finalize the draft of PROM which will be field−tested in an international study.

Conclusions: Measuring children's satisfaction with their prosthesis using a validated PROM is the first step towards improving satisfaction with prosthesis. This is the first study to develop a PROM by directly engaging children with a prosthesis during the development and validation of this new PROM. Once complete, this tool will support patient−centered care and help improve outcomes for children with limb differences.

Press−fit Osseointegration for Amish Patients

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Question: Press−fit transcutaneous osseointegration allows for a direct transcutaneous skeletal connection between a prosthetic leg and the residual bone, offering enhanced mobility, balance, proprioception, and relief of common difficulties with socket use. The use of this procedure is growing in many patient populations, including the people of Amish and related denominational lifestyle. This study aims to evaluate the outcomes of and perspectives on transcutaneous osseointegration among Amish patients.

Answer: A retrospective review was performed of all our osseointegration patients who expressed Amish lifestyle. Complications such as periprosthetic fracture or subsequent surgery were identified. Additionally, qualitative interviews were performed to assess attitudes around and satisfaction with osseointegration.

Results: Twenty patients were identified, all with unilateral lower extremity osseointegration. Indications for osseointegration included poor socket fit (13), pain (15), skin irritation (12), and mobility limitations (12). 16 reported working medium to high demand professions. One patient (5%) had a postoperative adverse event. His implant fractured after 19 months when his horse violently pulled him while driving his wagon. This was managed with implant extraction, antibiotic depot, and revision osseointegration after two months. There were no other complications. All patients reported being satisfied or very satisfied with their osseointegration procedure and all reported that they would probably or definitely have the same procedure again.

Conclusions: Transcutaneous osseointegration appears safe and enabling for patients living an Amish lifestyle. There were no apparent risks or complications that appeared unique to this patient population.

Assessment of Outcomes by Surgical Technique for Infected Nonunion and Malunion

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Question: To compare the efficacy of open reduction internal fixation (ORIF), intramedullary nailing (IMN), and external fixation in the management of infected nonunion and malunion.

Answer: This retrospective cohort study included adult patients undergoing corrective surgery for chronic septic nonunion or malunion at a single academic center between January 2013 and July 2024. Infection was defined as positive preoperative or intraoperative cultures or a high degree of suspicion by the treating surgeon. Demographic (age, sex, race, ethnicity, insurance, etc.) and clinical course details were collected via chart review. Postoperative outcomes (e.g. union, complication, rehospitalization, and reoperation rates) were analyzed for patients with at least 90 days of follow–up after definitive surgery. Statistical analysis was performed using R (version 4.4.0). Fisher's exact test was employed to assess significance for categorical variables, and Kruskal–Wallis test was used for continuous variables.

Results: Sixty–one patients were identified (IMN 59.0%; ORIF 21.3%; external fixation 19.7%). No demographic differences were observed between surgical techniques. Nonunion cases with the presence of deformity were more often managed with external fixation than ORIF or IMN (44.4% vs 16.7% vs 38.8%, $p=0.001$). There were no differences in median time between presentation and definitive surgery or median time to union. However, external fixation patients had a significantly increased total length of stay across all admissions compared to IMN and ORIF (36.5 vs 11 vs 8 days, $p<0.001$) as well as a greater number of total operations (5.5 vs 2 vs 1, $p<0.001$). No differences were observed in postoperative complications, rehospitalization, or unplanned return to operating room, and rates of successful union within one year were also similar (for patients with at least one year of follow–up). Additionally, there were no differences between surgical techniques with respect to loss to follow–up rates among all patients.

Conclusions: Patients with septic nonunion or malunion experience increased cumulative length of stay and number of operations when treated with external fixation, but outcomes and follow–up rates are comparable to other techniques. Characteristics such as deformity or bone defect may necessitate its use in the setting of chronic infection.

Role of Psychoeducational Coloring Book Tool in Limb Lengthening and Reconstruction Preparation for the Young Child

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Question: Limb lengthening and reconstruction (LLR) is arguably one of, if not the most, demanding orthopedic treatments for pediatric patients and families. Managing a lengthening/correction prescription, physical therapy exercises, weightbearing expectations, and pain management, all within the context of a child' s greater cognitive, social, and emotional development is often a significant burden for families. It may feel especially challenging to navigate this process with a very young child, whose cognitive abilities, executive functioning, behavioral regulation skills, and emotion regulation skills are all still developing.

Psychoeducational assessment and preparation for children and families planning for surgical treatment is increasingly recognized as a valuable dimension of standard of care. To this end, psychology, social work, and child life specialists are often embedded members of interdisciplinary teams. Perhaps unsurprisingly, however, there are scant psychoeducational tools available to prepare young patients for LLR treatment.

With this in mind, our team created a psychoeducational coloring book tool to assist with the developmentally–appropriate treatment preparation of very young children (ages 3–6) in anticipation of LLR. Our question was whether the coloring book tool was deemed acceptable and appropriate by patients and families as part of the treatment preparation process.

Answer: Our team of multidisciplinary experts, composed of pediatric orthopedic surgeons, pediatric psychologists, advanced practice providers, nurses, and child life specialists collaborated to create an educational coloring book detailing the process of LLR. This tool was grounded in the team's collective clinical and research experience and provided to patients (ages 3–6 years) and families undergoing LLR treatment at our pediatric orthopedic institution. Patients and families were asked seven questions regarding the suitability, acceptability, and appropriateness of the educational coloring book, and their responses were deidentified and collated.

Patients and families undergoing LLR received the coloring book and agreed to provide feedback on its contents. All families considered the psychoeducational tool acceptable. Further, all families described the tool as appropriate. Families reported that they considered the coloring book a helpful tool in facilitating conversation with their child regarding the details of treatment and normalizing use of an external fixator. Similarly, families noted that the coloring book elicited questions from their children that prompted helpful treatment discussion. Families also reported that their children enjoyed sharing the coloring book with siblings and extended family members to teach them about LLR. Finally, families reported that they appreciated having the medical team member "baseball cards" to learn more about their care team.

Role of Psychoeducational Coloring Book Tool in Limb Lengthening and Reconstruction Preparation for the Young Child *continued*

Whitney M. Herge, PhD; Mikhail Samchukov, MD; Alexander Cherkashin, MD; Elizabeth Hubbard, MD; Emily Elerson, RN; Meghan Wassel, David A. Podeszwa, MD
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Suggested changes to the coloring book included potentially shortening the book, acknowledging the variability of treatment (e.g., one family noted that their child did not stand for radiographs; one family noted that their child completed turns on their frame utilizing a wrench), and adding bonus coloring sheets.

Conclusions: The psychoeducational coloring book tool developed by our limb lengthening and reconstruction team for young children appears provisionally acceptable and appropriate to patients and families. Beneficial changes, such as acknowledging the variability of treatment details, were suggested.

Next steps include ongoing data collection at our institution, as well as from interested limb lengthening and reconstruction teams at other institutions with similar patient populations.

Determining the Rate, Effectiveness, and Complications of Leg Length Discrepancy Correction using Plate and Screw Physeal Tethering Temporary Epiphysiodesis in Young Children

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Question: Few studies have documented the use of plate and screw physeal tethering temporary epiphysiodesis as a treatment for leg length discrepancies (LLD) in young children. Untreated LLD can affect posture and biomechanics, leading to unequal limb length, back and leg pain, and antalgic gait patterns of varying severity. LLDs are attributable to several causes, including congenital, developmental, and acquired conditions. For those with minor LLDs, conservative treatments such as shoe lifts or orthotics are available. Other patients could benefit from surgical intervention to improve their LLD. Early intervention can be critical to limiting the broad−ranging impacts of LLD. The primary objective of this study is to examine the efficacy of using temporary epiphysiodesis in young children with leg length discrepancy. The secondary objectives are to describe the rate of leg length correction, define complications of temporary epiphysiodesis, and describe the frequency of occurrence.

Answer: A retrospective serial chart review design study was completed, examining the efficacy of treating pediatric LLDs with temporary epiphysiodesis using a plate a screw construct. Children who are 0−10 years of age who have been treated with temporary epiphysiodesis, identified through CPT codes, were included in this study. Pertinent data, including patient demographics, LLD etiology and details, operative reports, post−operative complications, and measurements, were collected and reviewed by study staff. Collected data was analyzed using descriptive statistics to understand the efficacy of temporary epiphysiodesis as an LLD treatment in young pediatric populations and treatment−related outcomes. Assessing efficacy requires the actual improvement divided by the expected theoretical improvement after epiphysiodesis, then multiplying by the percentage growth responsible for either the femur or tibia. Efficacy was quantified using the Multiplier Method and the formula (Lth−Lr)/([Lth−Li]x0.7) for distal femoral epiphysiodesis and (Lth−Lr)/([Lth−Li]x0.55) for proximal tibial epiphysiodesis.

Results: A total of 4 patients (2 boys, 2 girls) and 7 bone segments (4 femurs, 3 tibias) were included in the study. The mean age of the patients at initial surgery was 9.38 years. All surgeons used the plate and screw physeal tether surgical technique when conducting the temporary epiphysiodesis surgery. The etiology of LLD varies per patient. TEX001 had a congenitally short femur and hemimelia; TEX002 had amyoplasia in addition to other diagnoses, while the last participants, TEX003 and TEX004, both had hemihypertrophy. Right and left femoral efficacies were averaged from TEX001 (81%), TEX002 (78%), TEX003 (116%), and TEX004 (102%). Tibial efficacies were also measured, TEX001 (144%), TEX003 (145%), and TEX004 (129%). TEX002 did not receive the temporary epiphysiodesis procedure of the tibia. Efficacy calculated 6 months post−operatively showed a right femoral efficacy mean of 108% and a left femoral efficacy mean of 109%. Right and left tibial efficacy only included patients TEX001, TEX003, and TEX004.

Determining the Rate, Effectiveness, and Complications of Leg Length Discrepancy Correction using Plate and Screw Physeal Tethering Temporary Epiphysiodesis in Young Children *continued*

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Means included 157% right tibial efficacy and 152% left tibial efficacy at six months. Our efficacy values for one year included patients TEX001, TEX003, and TEX004. The average right femoral efficacy at one year was 91% and the left, 95%. Right and left tibial efficacy was 142% and 137%, respectively. Lastly, efficacy was measured at 1 year and 6 months with patients TEX003 and TEX004, measuring 95% for the right femur and 93% for the left femur. Tibial mean efficacies included 129% and 118% for right and left tibias, respectively. All patients had variable levels of growth as TEX001 had an overall right femoral growth of 2.9cm and right tibial growth of 1.1 cm. TEX002 had right femoral growth of 5.5 cm and TEX003 had left femoral and tibial growth of 1.9cm each. Lastly, TEX004 had right femoral growth of 4.9cm and 3.7cm of tibial growth. Complications identified in this study included genu varum, genu valgus, and the need for revision surgery. All patients experienced at least one complication postoperatively; ¾ had an unexpected revision surgery, ½ developed genu varum and ¼ had acquired genu valgus. Complications were noted to arise, on average of 397 days postoperatively. Notably, ¾ of patients developed angular deformities associated with plate and screw physeal tethering fixation.

Conclusions: In general, the temporary epipshysiodesis procedure using plate and screw physeal tethering was effective. However, it was associated with a high complication rate and unexpected revision surgery. This is a limited case series, and we plan to perform a multi−center study to include more patients. This study does raise the question if temporary epiphsyiodesis should be performed, or an appropriately timed permanent physeal ablation would be a better option.

Figure 1. Efficacy of Plate and Screw Physeal Tethering Over Time

	6 months	1 year	1.5 years
Femur	L:109% R:108%	L: 95 % R: 91%	L: 93% R: 95%
Tibia	L: 152% R:157%	L: 137% R:142%	L: 118% R: 129%

The Impact of Orthopedic Surgeon Training in Trauma and Deformity Correction in the Management of Nonunion and Malunion

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Question: To determine whether trauma and deformity correction training among orthopedic surgeons influences the management, clinical course, and outcomes of patients undergoing surgical treatment for nonunion and malunion.

Answer: This retrospective cohort study included adult patients undergoing corrective surgery for traumatic or iatrogenic nonunion or malunion at a single academic center between October 2014 and July 2024. Demographics (age, sex, race, ethnicity, insurance, etc.) and clinical course details were collected via chart review. Postoperative outcomes (union, complication, rehospitalization, and reoperation rates) were analyzed for patients with at least 90 days of follow–up after the definitive surgery. Statistical analysis was performed using R (version 4.4.0). Chi–squared test was employed to assess significance for categorical variables, and Mann–Whitney U test was used for continuous variables.

Results: Two hundred forty–six nonunion and malunion patients were identified; 46.3% were treated by a single orthopedic surgeon trained in trauma and deformity correction, 5.3% were treated by trauma–trained orthopedic surgeons, and 48.4% were treated by non–trauma–trained orthopedic surgeons. Patients treated by the orthopedic surgeon trained in trauma and deformity correction had an overall longer median time from injury to surgery compared to those treated by trauma–trained and non–trauma–trained surgeons (367 vs 274 vs 264.5 days, $p = 0.049$). However, patients treated by trauma–trained orthopedic surgeons exceeded those treated by the trauma plus deformity correction–trained surgeon and the non–trauma–trained surgeons with respect to time to union (318.5 vs 270.5 vs 210.5 days, $p = 0.022$) and total length of stay across all admissions (9 vs 5 vs 2 days, $p < 0.001$). No differences were observed in total number of procedures, union rates, length of follow–up, loss to follow–up, postoperative complications, rehospitalizations, or unexpected return to operating room. For all outcomes, bivariate analysis showed no statistically significant differences when comparing training in trauma versus training in trauma plus deformity correction.

Conclusions: The findings of this study suggest that orthopedic training in trauma plus deformity correction, although often equating to a more complex patient population, allows for relatively equivalent outcomes when compared to nonunion and malunion patients treated by orthopedic surgeons with and without trauma fellowship training.

Unusual Distribution of C. acnes Infection after Surgery in Patients from The Middle East

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Question: Post−operative infection is a well known complication after orthopedic surgery. Obtaining intraoperative cultures is essential for identifying the bacteria responsible for infection which dictates antibiotic therapy. Being able to predict infectious organisms in different patient populations can be helpful for prophylactic intraoperative management and setting of postoperative expectation. The purpose of this study was to analyze intraoperative culture data from Middle Eastern patients who underwent orthopedic surgery at our practice and compare these results to an historical control cohort.

Answer: Medical records of 136 Middle Eastern patients were retrospectively reviewed, identifying 17 patients (12.5%) who had positive intraoperative culture results. Main outcome measures included the types and prevalence of each microorganism cultured. Additionally, comparison of the prevalence of microorganism cultures was performed between the Middle Eastern patient cohort and the historical control cohort, which included 67 patients.

Results: The most commonly cultured microorganism in the Middle Eastern patient cohort was Cutibacterium acnes with 8 of the 17 patients with positive intraoperative cultures (47.1%) growing C. acnes. This was significantly higher than the 0/67 patients that grew C. acnes in the historical cohort ($p<001$). The other common microorganisms grown in our cohort were Staphylococcus epidermidis (17.6%) and Staphylococcus aureus (17.6%). None of these were significantly different from the historical control cohort in which the prevalence of Staphylococcus epidermidis was 20.9% ($p=1.0$), Staphylococcus aureus was 9.0% ($p=0.378$).

Conclusions: This study reports a significantly different distribution of infectious organisms with a higher prevalence of Cutibacterium acnes (C. acnes) in the intraoperative cultures from Middle Eastern patients who underwent orthopedic surgery as compared to a historical control cohort. These findings may warrant population−specific preoperative and/or perioperative management strategies. Further investigation is required to determine the underlying factors that contribute to the different microorganisms cultured in this cohort.

DF2 Brace vs Spica Cast for Pediatric Femoral Shaft Fractures

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Question: Femoral shaft fractures are the leading cause of pediatric orthopedic hospitalization. The DF2 functional brace offers a potential alternative to traditional spica casting, which, while effective, has challenges. This study compares outcomes and complications between the DF2 brace and spica casting in the management of pediatric femoral shaft fractures.

Answer: A retrospective matched cohort study analyzed 42 patients aged 1−5 years with diaphyseal femur fractures (OTA 32) treated between September 2021 and August 2024. Twenty−one patients treated with the DF2 brace were matched with 21 spica cast patients based on age, weight, and fracture characteristics. Primary outcomes included fracture union, time to weight−bearing, and radiographic alignment. Secondary outcomes encompassed hospital admission rates, length of stay, and complications.

Results: Demographics were similar between groups (mean age 2.3 years, 78.6% male). Hospital admission rates were significantly lower in the DF2 group (33.3% vs 71.4%, p=0.013) with shorter mean length of stay (0.33 vs 1.10 days, p=0.015). Notably, 95.2% of spica cast patients required an operating room compared to none in the DF2 group. All fractures achieved radiographic union at 6 weeks, with similar time to brace/cast removal and weight−bearing (DF2: 40.9 days, Spica: 40.1 days, p=0.715). Changes in angulation from initial to final radiographs were similar between groups in both planes. The DF2 group experienced more emergency department returns (3 vs 1), while the spica group had two cases of skin breakdown.

Conclusions: The DF2 brace demonstrated comparable union rates and alignment to spica casting while reducing hospital admissions, length of stay, and need for operative intervention. Although the DF2 group had more unplanned emergency department visits, the overall complication profile was similar between groups. These findings suggest the DF2 brace represents a viable alternative for pediatric femoral shaft fractures, potentially optimizing healthcare resource utilization without compromising treatment efficacy.

Loss to Follow–Up: Are Those Treated for Nonunion More at Risk?

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Question: Loss to follow–up can significantly impact patient outcomes in the treatment of limb deformities. Patients with chronic fractures may have had limited engagement in their initial fracture treatment, possibly contributing to treatment delays and the chronicity of their condition. As a result, they may be at higher risk for continued inconsistent follow–up. This study aims to determine if patients treated for chronic fractures experience different rates of loss to follow–up than those treated for acute fractures.

Answer: We conducted a retrospective analysis of all adult patients with fracture nonunion or malunion of any bone who underwent surgical correction at a single center in an underserved urban community between November 2015 and June 2024. We also conducted a retrospective analysis of all adult patients who underwent open reduction and internal fixation (ORIF) for ankle fractures at the same center between September 2016 and June 2023. The nonunion/malunion group was compared with the primary ankle ORIF group, which served as a sample of acute fractures. Primary outcomes include loss to follow–up within 6 months of surgery and at any point during the treatment course. Demographic variables including race, ethnicity, spoken language (English vs. non–English), and Distressed Community Index (<75 vs. ‰¥75) were controlled for if significantly associated with loss to follow–up. Outcomes were analyzed using Chi–Square tests.

Results: Of 242 patients undergoing nonunion or malunion surgery, 36.9% (n = 89) were lost to follow–up [20.7% (n = 50) within 6 months]. Of 941 patients undergoing ORIF for ankle fractures, 35.5% (n = 334) were lost to follow–up [25.0% (n = 236) within 6 months]. Of the demographics considered, only spoken language was significantly associated with loss to follow–up overall ($p = 0.015$) and within 6 months ($p = 0.038$). We controlled for this by analyzing English–speaking and non–English–speaking patients separately. Analysis revealed no statistically significant difference in loss of follow–up between groups within 6 months of surgery ($p = 0.509$, $p = 0.487$) and at any point ($p = 0.171$, $p = 0.837$) for both English–speaking and non–English–speaking patients, respectively.

Conclusions: The proportion of patients lost to follow–up after surgical treatment for nonunion or malunion is comparable to those treated for acute ankle fractures, suggesting that fracture chronicity is not a factor in loss to follow–up. Patients treated for nonunion or malunion may experience similar barriers to follow–up when compared to patients being treated surgically for acute fractures.

Role of 3D Modelling in an Accurate Deformity Assessment and Correction

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Question: In recent years, the prominence of 3D modelling in medicine has surged, particularly in pre–surgical deformity evaluation and correction. This technology enables a thorough analysis of a patient's anatomical structure, offering detailed insights into the deformity's nature and scope. Its integration has transformed surgical planning, benefiting both patients and surgeons by facilitating precise assessments and personalised surgical plans, thereby diminishing risks and enhancing outcomes. We report the advancements in 3D modelling and its relevance to limb reconstruction surgery for patient assessment and management. 1) what is the method our team has developed to integrate this technology into orthopaedic surgery 2) what are the outcomes of the patients who have been treated following this method.

Answer: Our approach involved utilising various software tools for corrective alignments and pre–surgical assessments, with Materialise and 3–Matic emerging as the most effective options. These tools deliver precise outputs, aiding orthopaedic surgeons in evaluating patient deformities accurately. By quantifying diverse parameters and integrating them into deformity analyses, virtual surgery simulations enable iterative processes to minimize intraoperative risks. Additionally, the growing accessibility of 3D printing technology has enhanced our ability to execute deformity correction surgeries through the provision of 3D–printed guides.

Results: The utilisation of 3D modelling has not only facilitated the customisation of implants but has also significantly enhanced our capacity to assess and rectify deformities accurately. This has resulted in improved patient outcomes and reduced surgical risks. Our team has leveraged 3D modelling technology to implement various techniques, enabling the detailed assessment of deformities and the development of custom patient–specific guides and implants. Through these demonstrations, we aim to underscore the transformative potential of 3D modelling in medicine.

Conclusions: Patients who have been treated with our method have proved integration of this technology can take surgeries and treatment to a new length. There is further scope of expanding this area and ways to better integrate this technology into orthopaedic surgery where it can allow surgeons to develop a comprehensive treatment plan for complex limb reconstruction prior to surgery and achieve better patient outcomes.