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CAMPBELL ORTHOPAEDIC JOURNAL

Volume 3, May 2017

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Campbell Clinic Orthopaedics • The Campbell Foundation
University of Tennessee-Campbell Clinic Department of Orthopaedic Surgery & Biomedical Engineering

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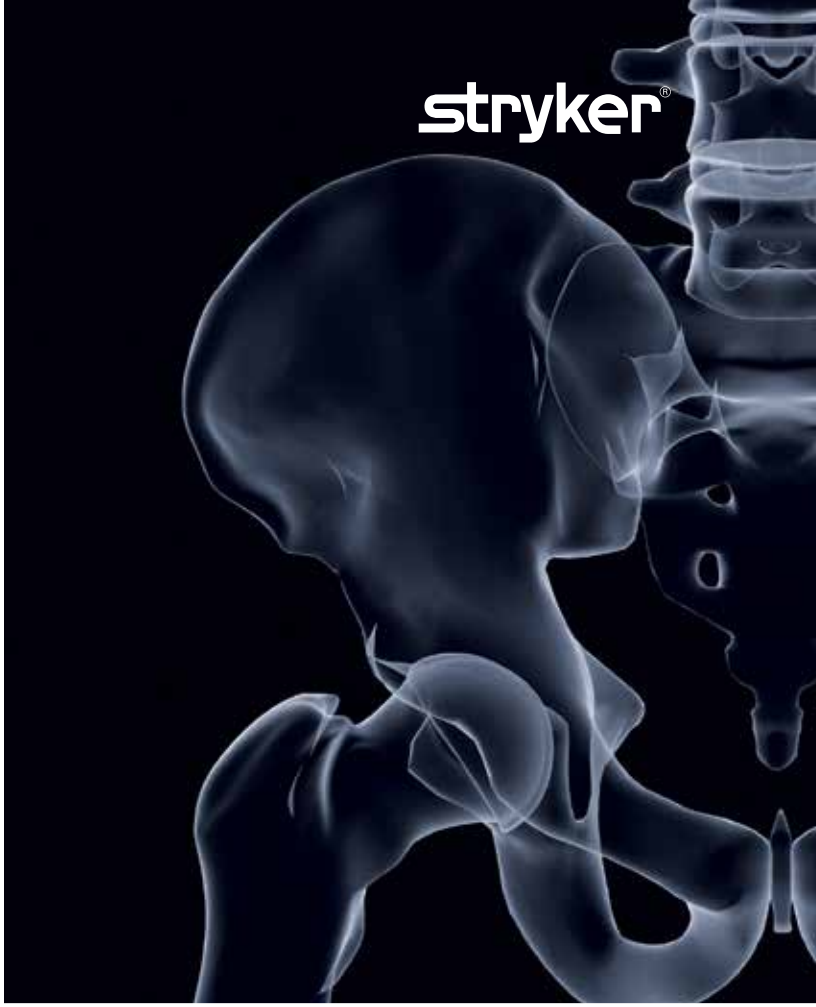

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[1] R. Papannagari, G. Hines, J. Sprague and M. Morrison, "Long-term wear performance of an advanced bearing knee technology," ISTA, Dubai, UAE, Oct 6-9, 2010.
[2] Australian Orthopaedic Association National Joint Replacement Registry Annual report. Adelaide: AOA; 2012.

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Letter from the Editor-in-Chief

S. Terry Canale, M.D.

Campbell Foundation President

May, 2017

Dear Colleagues,

It is with great honor that I present to you the 3rd volume of the *Campbell Orthopaedic Journal* (COJ). Those of you who know me, know how I love the "rule of 3" in orthopaedics, so I'm delighted that we've reached this milestone. I'm a big believer in research to not only find solutions to clinical problems, but also to provide insights to the researcher - about himself. A friend of mine likes to say, "Nothing is worse for results than long-term follow-up." When we genuinely pause to reflect on our work, and really study it, we gain insights that can guide our next steps. Then, new questions emerge, and the cycle repeats.

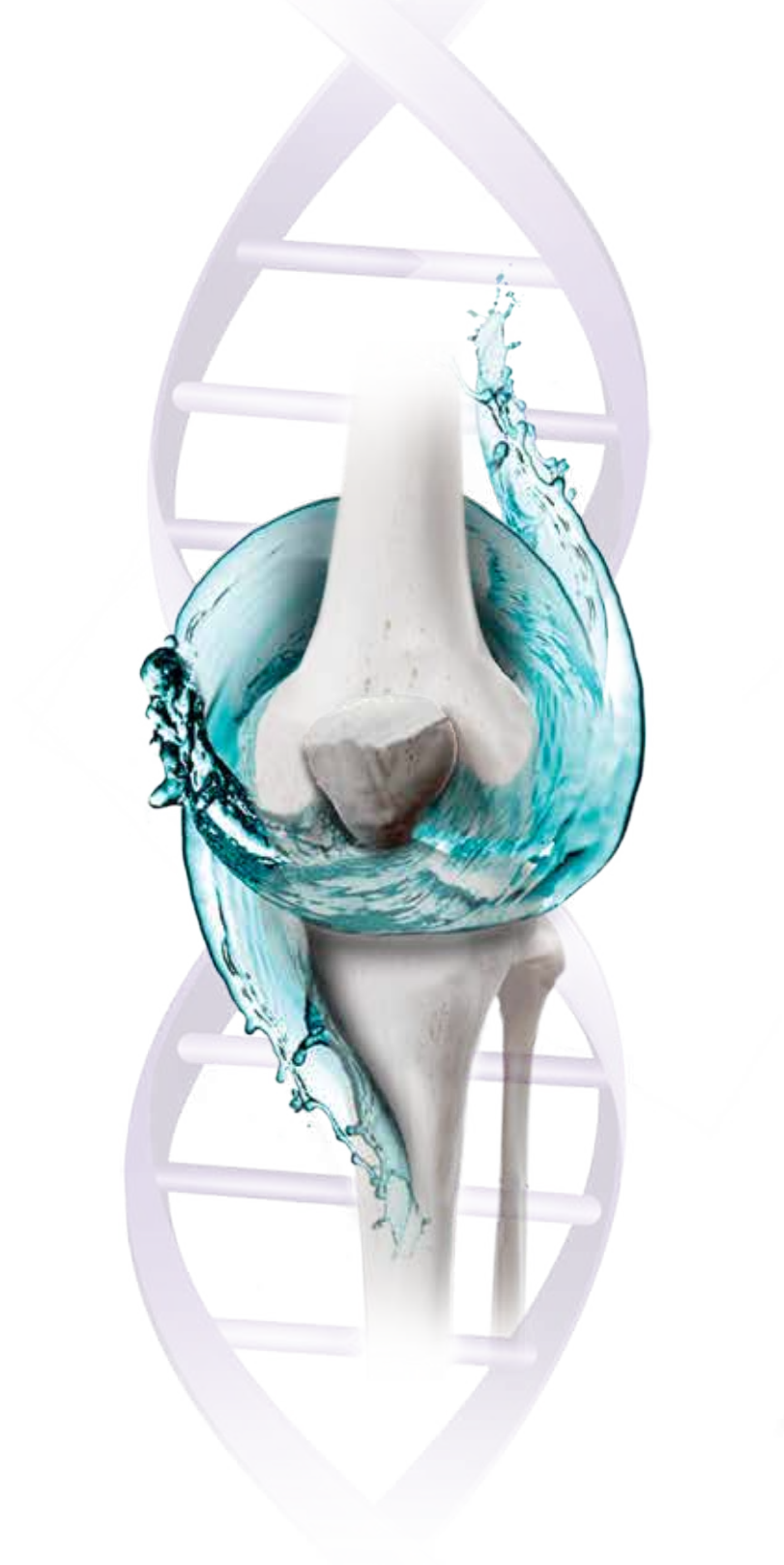
I was inspired to begin this publication in 2015 to highlight the excellence that I have observed year after year among our staff and students. Their ongoing commitment to research translates to providing excellent, patient centered care and continues to impact orthopaedics locally and around the globe. I'm proud to report that the work continues, bringing new insights - and more questions - for patients every day.

Like triangulation, three-point fixation, and three planes in space define a point, so, too, this third edition of the Campbell Orthopaedic Journal highlights the breadth and array of research underway every day here.

We are pleased to share this research with you. At Campbell Clinic, we are a family who enjoys showing off the accomplishments of our current residents while keeping track of those who have left the nest.

As you enjoy the 2017 edition, I hope that you are inspired to be a leader in the care that you give and the lives that you touch. And, if you wish to share your own "rule of three" in orthopaedics with me, please let me hear from you!

Sincerely,
S. Terrence Canale, MD, Editor-in-Chief
Campbell Foundation President



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References: 1. Bioventus LLC. Sinovial Sales Data. Data on file, RPT-000529. 2016.* **2.** Pavelka K, Uebelhart D. Efficacy evaluation of highly purified intra-articular hyaluronic acid (Sinovial) vs hylan G-F20 (Synvisc)in the treatment of symptomatic knee osteoarthritis. A double-blind, controlled, randomized, parallel-group non-inferiority study. *Osteoarthritis Cartilage*. 2011;19(11):1294-300.

* Sinovial is branded as GELSYN-3 in the United States.

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Departmental Update from the Chairman

James H. Beaty, M.D.

Department Chairman, Harold B. Boyd, M.D. Professor
UT-Campbell Clinic Department of Orthopaedic Surgery and Biomedical Engineering
University of Tennessee Health Science Center

Last year, I noted that Chairman Emeritus S. Terry Canale, MD, had left the Department in fine shape. Since that time, I have enjoyed learning the extent to which this statement is true. There is considerable breadth and depth of experience in the Department, with our scientists making genuine progress in both translational and basic science pursuits related to the genetic, individualized and cellular influences on bone and soft tissue mechanisms of injury, and healing. Their work offers the promise of discoveries that clinicians will be able to provide for their patients who are limited by musculoskeletal diseases, disorders, and conditions.

RESEARCH

As we near the end of the 2016-2017 academic year, the department consists of nine full-time basic science researchers: Hongsik Cho, PhD, Denis DiAngelo, PhD, Weikuan Gu, PhD, Karen Hasty, PhD, Yan Jiao, MD, Susan Miranda, PhD, Richard Smith, PhD, and Brooke Sanford, PhD; along with clinician scientist, Bill Mihalko, MD, PhD. This includes three Chairs of Excellence:

- George Wilhelm, Chair of Excellence,
- Harold Boyd Chair of Excellence and,
- Hyde Chair of Excellence.

Our scientists have robust extramural funding, including NIH R01 grants, and support from multiple other sources.

On the clinical side, our research effort has been equally impressive, with 104 scientific articles published in peer-reviewed publications, along with 79 podium presentations, and 32 posters highlighting our research presented at national and international meetings last year; representing a 10-30% increase in output. Campbell Clinic continues to collaborate in prominent multicenter studies, and we have attracted both industry- and government-sponsored clinical research studies and grants. Our team expanded last year with the addition of a fifth research coordinator.

EDUCATION

Musculoskeletal education from the department occurs at all post-graduate levels, including medical students, orthopaedic residents and fellows, engineers, clinical and research fellows, scientists and PhD candidates. On the scientific side, the Department oversees a joint MA and PhD program with the University of Tennessee and the University of Memphis. Drs. William Mihalko (University of Tennessee) and Gene Eckstein (University of Memphis) serve as Co-Directors.

Our orthopaedic surgical residency program is ranked in the top 10% nationally, with eight residents per class, in a five-year program. We are accredited through the Accreditation Council for Graduate Medical Education (ACGME), and present our students with a greater than 1:1 ratio of faculty to students. Instruction is provided in all orthopaedic subspecialties by Fellowship-trained orthopaedic surgeons. Dr. Thomas W. 'Quin' Throckmorton and Dr. Derek M. Kelly ably serve as Program Director and Assistant Program Director, and do an outstanding job in supervising and advising the residents. Fellowships in the subspecialties are available, and we average from 5-8 fellows per year.

Monday night continues as our traditional 2½ hour interactive didactic educational meeting sprinkled with case presentations. Weekly subspecialty conferences are held as well as a monthly journal club. The Visiting Professors Program is designed for distinguished orthopaedic surgeons to give "Grand Rounds" four times a year with our premier CME meeting, known as the Alvin J. Ingram Memorial Lecture held in the spring. Beginning this past fall, the Campbell Foundation initiated a Visiting Professor Lecture Series, funded with donor support. This important series, is open to area orthopaedic surgeons, nurses, physicians assistants, engineers and researchers, and brings prominent thought leaders in each orthopaedic subspecialty to Memphis for engaging discussions about important and challenging issues in orthopaedic subspecialties, and culminates in a lecture on a prominent topic within the subspecialty.

We continue to publish Campbell's Operative Orthopaedics every four years, with the 13th edition published in November 2016. The tome remains popular, and has surpassed sales of the prior edition in its first six months of release.

The department continues to make strong progress in education, research and innovation. We are well-positioned to advance toward the centennial anniversary of our residency training program in 2024. Dr. Campbell would be proud.

News from Campbell Clinic

Frederick M. Azar, M.D.

Chief of Staff, Campbell Clinic Orthopaedics
Professor and Sports Medicine Fellowship Director

Campbell Clinic has treated patients suffering from musculoskeletal injury and disease both locally and nationally dating back to 1909. The tradition of teaching and research begun by our founder, Dr. Willis C. Campbell, continues today. We offer one of the nation's most competitive residency and fellowship training programs in orthopaedics. This past year, we received more than 850 applications for one of our eight residency positions. We search for exceptional physicians who work to become skilled technicians, but who retain a balance between faith, family, and patient care.

Over the past year we have continued to grow our outpatient total joint and outpatient spine practice at our two Campbell Surgery Center locations. Patient satisfaction remains incredibly high thanks to convenient services delivered by a capable and compassionate staff that yield exceptional outcomes. We continue to see success in our "pre-hab" program for total joint patients as well. This service allows patients to visit with a physical therapist prior to total joint replacement surgery so that they can receive a take-home exercise program and begin "practicing" for life after surgery. Being able to anticipate and prepare for daily tasks around the house helps patients and their care-givers alike so rehabilitation best practices are already in place once they get home.

Additionally, we rolled out walk-in urgent care services at each of our five outpatient clinic locations. This has resulted in patients being able to seek specialized orthopaedic care for acute injuries on their schedule.

During 2016 we added three new highly skilled physicians to our practice. Dr. James N. Robinson joined Campbell Clinic after serving as team physician for The University of West Alabama in Livingston, Ala. In addition to serving as a team doctor for our area high schools, Dr. Robinson is the lead physician for our new walk-in clinic at our Germantown location.

Dr. Clayton C. Bettin joined the clinic in August as a foot and ankle surgeon after completing his fellowship at The University of Utah last year. He re-joins us in Memphis after having been in our residency program prior to his training in Utah, and he serves patients at our Medical Center and Southaven clinics.

We also welcomed Dr. Michael J. Beebe as a trauma surgeon. Dr. Beebe graduated from medical school at The University of Tennessee Health Science Center here in Memphis. He completed his residency at The University of Utah in 2015 and a fellowship in orthopaedic trauma at the Florida Orthopaedic Institute last year. He serves patients at our Medical Center clinic as well as Regional One Healthcare.

Our practice continues to look for opportunities to be innovative in our delivery of healthcare services. Campbell Clinic's participation in the BPCI program has provided excellent outcomes and has benefited our patients tremendously as well as our practice.

In a further effort to improve clinical outcomes, we created a comprehensive medical management program. Shelley Miller was hired as a clinical nurse practitioner to lead the program under the medical direction of Dr. Andrew Murphy. The orthopaedic medical management program was designed to optimize overall patient health by creating a specially tailored health action plan based on the patient's individual medical history.

Our staff starts this process with a patient by performing a general health assessment prior to surgery, followed by the development of an action plan to fully coordinate care between the patient's orthopaedic physician, primary care provider, and a team of other outside specialists as necessary. For example, it may be determined during the initial assessment that a patient experiences sleep apnea, suffers from dental disease and smokes routinely. For such a patient, the staff at Campbell Clinic might help set up consultations with a sleep specialist, dentist and smoking cessation professional or dietician. Our team follows up with the patient throughout the peri-operative and post-injury time frame to aid in compliance, provide support and answer patient questions. This program is still in its early stages but has been successful to date.

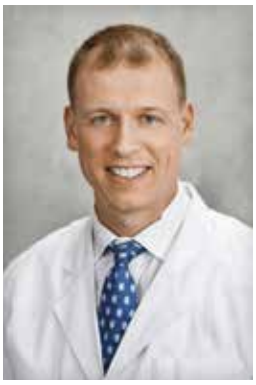
Preparing patients for success through the pre-hab and medical management programs positions them for a productive and healthy lifestyle after orthopaedic surgery. It is gratifying to be a part of a team that is committed to enhancing and improving the lives of the patients who entrust their care to us.

State of the Residency

Thomas W. 'Quin' Throckmorton, M.D.

Orthopaedic Residency Director, Professor

UT-Campbell Clinic Department of Orthopaedic Surgery and Biomedical Engineering



For nearly 100 years, the Campbell Clinic, in conjunction with the University of Tennessee-Campbell Clinic Department of Orthopaedic Surgery and Biomedical Engineering, has been proud to train orthopaedic surgeons from all over the country and, indeed, all over the globe. Over 550 orthopaedic surgeons have trained at our institution and our graduates include 8 presidents of the American Academy of Orthopaedic Surgeons (AAOS), 9 directors of the American Board of Orthopaedic Surgery (ABOS), 4 presidents of the American Orthopaedic Association (AOA), and numerous presidents of subspecialty societies. Surgeon education is a hallmark of our program, and the staff, in addition to our responsibilities for teaching our residents, continue to author Campbell's Operative Orthopaedics, now in its 13th edition. While orthopaedic knowledge continues to expand, our educational goal has remained constant: to produce excellent, well-rounded orthopaedic surgeons who have the opportunity to pursue the subspecialty training of their choice.

Our residents train in all orthopaedic subspecialties, both as junior and senior residents, and our rotations combine an exposure to the academic/tertiary medical center environment as well as the private practice setting. This comprehensive approach offers the ability to see all subspecialties from different angles and maximizes true understanding of orthopaedic principles and their application. Our training program is designed to prepare residents for the Orthopaedic In- service Training Examination (OITE) and Step I of the American Board of Orthopaedic Surgery examination, through a combination of Core Curriculum training combined with subspecialty conferences in trauma, pediatric orthopaedics, sports medicine and shoulder/ elbow surgery, hand surgery, foot and ankle surgery, and spine surgery. And in this era where medicine and business often intersect, we have augmented our curriculum with business training and an awareness of value as it pertains to orthopaedic care.

Additionally, we have focused on strengthening and building our clinical and biomechanical research infrastructure, which includes multiple research nurse coordinators, database access to track patient outcomes, a biomechanics laboratory and an extensive orthopaedic library staffed by a full-time librarian. We currently are conducting over 100 active clinical and biomechanical research projects. Investigators have been awarded funding from both internal and external sources to conduct these studies, in addition to additional extramural (NIH, NSF, etc.) awards among our basic science research staff. We have been committed to sharing our research at regional, national, and international meetings, and in academic and scientific publications. In 2016, the program published 104 papers and won the Charles S. Neer award for shoulder and elbow research and was named Best of the AAOS at the Annual Meeting in multiple categories.

Our international elective medical mission program continues, with sponsorship of an international community service medical mission. Our residents have served in Nicaragua, Guatemala, Honduras, Tanzania, and, this year, Kampala, Uganda. In this way, we imbue a commitment to community service within our residents.

This year,we will celebrate the graduation of our 92nd residency class, whose members are profiled within this publication. We are proud of these eight orthopaedic surgeons, who all matched into outstanding fellowship programs for subspecialty training. Their senior research efforts are depicted within these pages, and thousands of patients will benefit from the clinical discoveries these projects have yielded. Simultaneously, I am pleased to recognize the incoming Class of 2022 which will begin training in July. We are confident these exceptional young physicians will continue the tradition set forth by their predecessors.

In summary, we are proud of our heritage at the Campbell Clinic, but we are equally proud of our present and we look forward to our future. With our comprehensive, diverse, high-volume brand of training, we will continue to strive for excellence in the training of orthopaedic surgeons.

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Bonnie Simpson-Mason, M.D., CEO
Robert Gray, M.D.
Vani Sabesan, M.D.
J. Mandume Kerina, M.D.

"Economic Fundamentals of Orthopaedics"

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Alvin J. Ingram, M.D. Memorial Lecture
David A. Halsey, MD - Keynote Speaker

"Orthopaedic Advocacy at the National Level"

Professor, University of Vermont School
Department of Orthopedics and Rehabilitation
Attending, Martha's Vineyard Hospital
One Hospital Road
Oak Bluffs, MA 02557

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May 19, 2017
The Zone, FedEx Institute of Technology


Alvin J. Ingram, MD

Dedicated Lectureship Series:

Alvin J. Ingram, MD Memorial Lecture

Each year, the Campbell Foundation is privileged to host a Distinguished Professor in memory of a fine surgeon. The annual Alvin J. Ingram, MD Memorial Lecture was initiated in memory of former Campbell Clinic Chief of Staff and Department Chairman Alvin J. Ingram, M.D., through a gift from members of his family, to honor his commitment to education. Dr. Ingram was a graduate of our residency program, was a world authority on the treatment of polio.

The lecture series highlights achievements in surgeon education, and features a Keynote Address by a Distinguished Professor, followed by presentations from the Campbell Foundation graduating residents. Beginning in 2014, under the guidance of course director Derek M. Kelly, M.D., the Ingram Lecture was expanded considerably and included not only lectures by our Distinguished Professor, faculty and the residents, but also an Expert Panel and technical exhibits. This year, we will also display posters that highlight research from our Residents and Fellows. The Ingram Lecture is open to the public, with continuing education credits available for physicians and other allied health professionals. The Ingram Lecture regularly attracts an audience of more than 150 surgeons, engineers, scientists, and others dedicated to excellence in orthopaedics.

2016 Alvin J. Ingram, MD Memorial Lecture • May 20, 2016

Distinguished Professor: William M. Mihalko, M.D., Ph.D.
Professor & J.R. Hyde Chair
Chair, Joint Graduate Program in Biomedical Engineering
Campbell Clinic Department of Orthopaedic Surgery & Biomedical Engineering
University of Tennessee Health Science Center
Memphis, Tennessee


William M. Mihalko, MD, PhD

The 2016 Distinguished Professor, Dr. William M. Mihalko, Ph.D., is an internationally renowned expert in adult reconstruction who serves as a lecturer, editor, and leader in multiple professional societies. Dr. Mihalko has been ranked as one of the top 50 worldwide experts in knee arthroplasty by Expertscape.com for 2014, 2015, and 2016.

Dr. Mihalko's lecture, "Adverse Reaction to Metal Debris in TJA: A Cause for Concern?" discussed how metal debris and mechanically assisted crevice corrosion from modular taper junction in joint replacement implants can impact survivorship and outcomes. He described the driving mechanism of a hypersentivity reaction and how this cascade impacts potential failure of a joint arthroplasty. Teams led by Dr. Mihalko continue to investigate innovative diagnostic indicators of metal hypersensitivity, such as new biomarkers and genetic predilections that may allow for screening and personalized choices for implant materials in the future. Dr. Mihalko encouraged surgeons to be diligent in monitoring and reporting suspected reactions to corrosion from modular connections through the FDA MedWatch program so that the true incidence of these issues may be known in the future.

Another highlight of the 2016 Ingram Lecture was the presentation of the research of our graduating class of residents. Resident research at the Campbell Foundation

is only possible through donor support. These financial gifts offset the costs of research, including supplies, testing equipment and support personnel. In addition, through a gift from the family of Dr. Hugh Smith, the Hugh Smith Research Award is presented each year to the best research project, judged by a panel from the Ingram Lecture. Dr. Hugh Smith, a former Campbell Clinic Chief of Staff, and one of the founders of the Campbell Foundation, believed strongly in the power of innovation to unlock solutions to challenging clinical programs. Dr. Smith recognized the significant role that research can play in developing new surgical techniques and implants that will lead to a better quality of life for patients, and his family wanted to formally celebrate and recognize the importance of ongoing research. The panel of judges evaluated each presentation based upon the design, content, and originality of the research, clinical significance and potential for publication in a peer-reviewed journal. The 2016 Hugh Smith Presentation Award was presented to Dr. Tyler Brolin, for "Outpatient Total Shoulder Arthroplasty in the Ambulatory Surgery Center Environment is a Safe Alternative to the Inpatient Hospital Setting: A Matched Cohort Study".

2017 Alvin J. Ingram, MD Memorial Lecture • May 19, 2017

Distinguished Professor: David A. Halsey, M.D.

First Vice President, American Academy of Orthopaedic Surgeons
Attending Surgeon, Martha's Vineyard Hospital
Oak Bluffs, Massachusetts
Professor, University of Vermont School of Medicine


David A. Halsey, MD

David A. Halsey M.D. is the Attending Orthopaedic Surgeon at Martha's Vineyard Hospital in Massachusetts, as well as a Professor at the University of Vermont School of Medicine in Burlington, Vermont where he has been honored twice as "Teacher of the Year". He attended undergraduate school at Middlebury College, received a medical degree from Robert Wood Johnson Medical School, and trained in orthopaedic surgery at University of Vermont.

Dr. Halsey has over 25 years of experience in the treatment of hip and knee problems and is dedicated to helping patients "get back in the game." His caregiver team combines leading edge techniques with proven traditional methods to provide the best orthopaedic care possible, emphasizing a partnership with the patient.

Dr. Halsey is recognized as an expert in many non-medical issues that impact a physician's practice such as economic and value indicators of medical care, financial barriers, professional compliance, group purchasing, and orthopaedic advocacy. In 2017, Dr. Halsey was elected as First Vice President for the American Academy of Orthopaedic Surgeons (AAOS), and he will commence his Presidential term in 2018. In addition, he is a fellow in the American Orthopaedic Association, and the American Association of Hip and Knee Surgeons.

Dr. Halsey will participate in the 2017 Alvin J. Ingram Memorial Lecture and his Keynote Address will be "Orthopaedic Advocacy at the National Level".

Havana Is that You?

by S. Terry Canale, M.D.

The Campbell Clinic orthopaedic residency training program began in the early 1920s, and is considered one of the most outstanding orthopaedic residencies in the United States. The founders of Campbell Clinic established an alumni group called the Campbell Club that has met annually (usually at the AAOS annual meeting) since the 1930's. All Campbell Clinic alumni are members of the Campbell Club, and Campbell Clinic staff who trained elsewhere are honorary members. Every three years, a Campbell Club Triennial meeting is held, usually in Memphis, although they have had several meetings in resort areas in the Destin, Florida area on the Gulf Coast.

In 1955, a Triennial meeting of the Campbell Club was held in Havana, Cuba. Most of the Campbell Clinic staff and some alumni attended. It was hosted by **Mario Stone**, a Campbell Clinic graduate and a practitioner in Havana. Many excellent talks were given on orthpaedics, both by members of the Campbell Club and the Cuban Orthopaedic Society. Those in attendance included **J. Spencer Speed**, **Joe Frank Hamilton**, **Harold Boyd**, **Hugh Smith**, **Tom Waring**, **Robert Knight**, **Marcus Stewart**, **Al Ingram**, **Thurmon Crawford**, **Hoyt Crenshaw**, **Lewis Britt**, **Lee Milford**, and **Rocco Calandruccio**, to name a few. Of course Mario Stone was present as well as **Bland Cannon**, **R. C. Robertson**, **M. W. Ewing**, **Charles Brighton**, **Leon Hay**, **H. R. Gossling**, **Thurmon Crawford**, and **Beverly Ray**. Hosts from Cuba included Alberto Inclan, Professor of Orthopaedics at the University of Havana - and notably, uncle of current Campbell Clinic physician **Santos F. Martinez's** father.

The three day educational endeavor was outstanding. Even in that day, there was political talk about the future of Cuba. The Cuban hospitality was especially appreciated by all of the Campbell Clinic registrants. Dr. Rodrigues Gutierrez, Professor Isadoro Pascau, and many other Cuban orthopaedists were in attendance and contributed to the success of this meeting. The meeting was held in the Central Hotel in downtown Havana, the premier hotel in Cuba at that time. It was a hotel of the rich and famous, the playground of prominent vacationers to Havana, and a gambling hotspot. The venue featured excellent dining, night club life at the Club Tropicana, and beautiful beaches. The Campbell Club enjoyed the three-day meeting immensely and vowed to come back at a later point in time.

However, all that ended in 1959 with the Cuban Revolution with the overthrow of the Batista government by Fidel Castro, his brother, Raul Castro, and Che Guevara. I remember being in college on New Year's day 1959 at the Sugar Bowl in New Orleans where I witnessed numerous Cubans entering the football stadium in their tuxedos and evening gowns, having fled Cuba from New Year's Eve parties in Havana the night before.

The Castros established a socialist government that has survived the Bay of Pigs invasion and the Cuban Missile Crisis. I had an opportunity to visit Cuba when it was opened again to American visitors on educational tours. What a great experience and what a magical island. There are 11 million inhabitants of the island, and 2 million live in Havana. The majority of the population exists in a socialistic state and a great majority are uneducated and live in poverty. However, they are happy people. They laugh and sing and enjoy life as much as any group of people I have ever seen.

Accompanied by my daughter, we witnessed professional dance companies, professional jazz musicians, and the only women's vocal group ensemble. The educational tour was excellent, visiting the new American Embassy during the anniversary of the revolution and seeing the first American cruise ship to enter Havana Harbor in over 40 years. The food was fantastic, especially the seafood; with fresh lobster and other seafood delicacies daily. The Cuban music is everywhere on the island and like no other music I have ever heard.

Cuban people make use of everything available and, as a result, have produced a large population of artists of every type - painters, musicians, dancers. As relations with the United States warm, Cuba has become an entertaining and worthwhile place to visit.

Perhaps the Campbell Club could have a future Triennial meeting in Havana. What a festive occasion it would be to return to Havana after nearly three quarters of a century. The old Central Hotel with all its history and charm is still there, and the Havana beaches are pristine. Nothing has really changed since the revolution. It's as if Cuba is in a time warp. What a great thrill it would be to go back in time and have the Campbell Club meet again in Cuba.

A high point of a visit to central Havana is a ride in one of the U.S.-made taxis from the 50s. My daughter and I caught a ride in a pink 1955 Chevy taxi. After we got in the cab, the driver said, *"Señor, can you help me?"* I said, *"Well certainly."* Then the cab driver said, *"Get out!"* I got out and he said, *"PUSH!"* I started pushing the cab, he rolled a few feet, and he jump-started the cab and away we went in the '55 Chevy.

I said, *"Havana is that you?"*

A LEGACY OF VOLUNTEERISM

The Effect of a Helping Hand[1]

by S. Terry Canale, M.D.

Many are aware of the legacy of service to children and adults crippled by orthopaedic conditions that has been a part of the DNA of Campbell Clinic. However, sometimes, we are reminded of other parts of our legacy that are less often told. This story, shared by Dr. E. Anthony 'Tony' Rankin, MD, 2008 AAOS President, reminded us of a bit of our heritage.

It seems that Dr. Rankin was born in Holly Springs, MS, in a house built by his grandfather, Edgar Rankin, Sr., a carpenter. His grandfather was the son of a young mother who was born in slavery. Due to circumstances and lack of formal opportunity, he had little formal education; however, he became a community leader who valued hard work, honesty, and independence. Edgar Rankin, Sr. led voting registration campaigns and promoted access to voting rights for all.

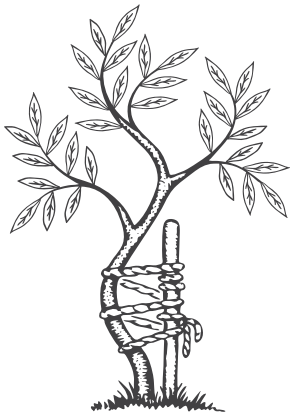
Dr. Tony Rankin's uncle volunteered for the US Army during World War II and served with distinction, so much so that it inspired Dr. Rankin to apply to Walter Reed Army Medical Center for his orthopaedic training.

Dr. Rankin's father, Edgar E. Rankin, Jr., was ineligible for military service due to the residuals of an open tibial fracture from a college football injury in the preantibiotic era. When he sustained the injury, the proximal tibial fragment stuck in the ground of a cow pasture that doubled as a local football field. His leg, and probably his life, was saved through the charitable act of an orthopaedic giant, **Willis C. Campbell, M.D.**

Dr. Campbell volunteered his services and his expertise at the small segregated Collins Chapel Hospital in Memphis, Tennessee. Dr. Rankin's father recalled in later years that Dr. Campbell made weekly rounds and advised the lone black physician, Dr. Collins on the ongoing treatment of his badly injured leg. As Dr. Rankin states, *"Were it not for Dr. Campbell's volunteer spirit, my father could not have grown into healthy adulthood, fully able to provide for his family, to become an educator, and in turn, to make his contributions to society. The total effect of the helping hand can indeed have an untold beneficial effect on the lives of others."*

As we go about our busy days, treating patients, performing surgery, attending to the "business side" of orthopaedic medicine, we are reminded to pause to reflect on our heritage, and to do our part to sustain the legacy established by our founder, Willis C. Campbell, MD, to provide access to excellent orthopaedic care to all.

[1]Exerpted from Dr. Tony Rankin's 2002 Presidential Address to the Eastern Orthopaedic Association's Annual Meeting



CLASS OF 2017 RESIDENT RESEARCH

Hyaluronic Acid Injections of the Knee: Predictors of Successful Treatment

ABSTRACT

Background: Knee viscosupplementation yields variable results for osteoarthritis. Establishing patient and treatment factors that predict a favorable response to intra-articular hyaluronic acid (HA) treatment will better guide patient and treatment selection.

Methods: This prospective study evaluated patients presenting with Kellgren-Lawrence grade 1-3 painful, primary knee osteoarthritis. The primary outcome measures were the Western Ontario and McMaster Universities Arthritis Index/ Knee Injury and Osteoarthritis Outcome Score (WOMAC/KOOS) and a standardized visual analog scale (VAS). Surveys were completed at the first and subsequent injections, then at three months post-treatment. Response to treatment was defined according to the Osteoarthritis Research Society International 2004 criteria.

Results: We enrolled 135 patients, 102 remained for final analysis at minimum three-month follow-up. Fifty-seven percent of patients had a positive response to treatment. Factors related to a positive response included those with grade 1 or 2 osteoarthritis (RR=2.17; 95%CI, 1.40-3.37), and those who showed improvement after the first injection (RR=2.22; 95%CI, 1.49-3.31). Seventy-eight percent of people who responded to the first injection had a positive response at follow-up. In multi-variable analysis, those aged 60 or older responded more positively with grade 2 osteoarthritis than those less than 60 years (RR=1.98; 95%CI, 1.18-3.21). Gender, race, BMI, smoking status, HA brand, and initial VAS and KOOS scores were not significant predictors of success in either independent or multivariable analysis. The VAS strongly correlated with KOOS pain scores as well as successful outcomes.

Conclusion: Patients with mild to moderate osteoarthritis (grades 1 and 2), and those who responded positively to the first injection were two times more likely to respond positively to the injection series than those with grade 3 osteoarthritis, or those who did not respond initially. Patients aged 60 or older are twice as likely to respond positively than those less than 60 years for grade 2 osteoarthritis. The VAS may be a reliable method of defining and monitoring treatment success. Judicious patient selection and counseling may improve outcomes associated with intra-articular HA injections.

Level of Evidence: Level II, Therapeutic

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Reconstruction of Proximal Humeral Bone Loss With a Reverse Total Shoulder Prosthesis Using a Modular Endoprosthetic Reconstruction System: Preliminary Results

ABSTRACT

Background: Traditional methods of dealing with proximal humeral bone loss, including resection arthroplasty, arthrodesis, reconstruction with tumor endoprosthesis and endroprosthesis-allograft composite, and more recently reverse total shoulder arthoplasty, have had mixed results in the restoration of function, and high rates of complications have been reported. Osteoarticular allografts and allograft-prosthesis composites have decreased the rate of instability, but have introduced another set of complications, including subchondral collapse, fracture, nonunion, infection, and late-onset arthrosis. To restore length and avoid allograft nonunion and instability, implants have been designed that combine a reverse total shoulder arthroplasty prosthesis with a modular endoprosthetic reconstruction system.

Purpose: The purpose of this study was to evaluate the outcomes of reconstruction with one such device in patients with massive proximal humeral bone loss.

Methods: Data were collected prospectively from two institutions for all patients with massive proximal humeral bone loss who had reconstruction with a reverse total shoulder arthroplasty using a modular endoprosthetic system. A single system was used in all patients (Comprehensive® Segmental Revision System, Zimmer Biomet, Warsaw, IN, USA). The primary outcome measure was failure of the reconstruction, defined as need for revision surgery or radiographic evidence of component failure. Preoperative and postoperative functional outcomes were compared, including range of motion and strength. Patient-reported outcomes, determined through preoperative and postoperative quickDASH scores, ASES scores, and visual analog scores (VAS), also were compared.

Results: Eleven patients met the inclusion and exclusion criteria: 7 females and 4 males with an average age of 68.5 years (range, 22 to 79 years). The most common reason for proximal bone loss was failure of a previous arthroplasty procedure, which occurred in 6 patients. Average forward flexion and average post-operative internal rotation improved significantly (Table 1), as did the average quickDASH and average ASES scores. Average post-operative external rotation demonstrated no statistically significant improvement. Pain, as determined by the visual analog score, also improved significantly.

Forward flexion		Internal rotation		External rotation	
Preop	Postop	Preop	Postop	Preop	Postop
20.6 degrees (0-45)	96.8 degrees (40-170)	21.6 degrees (0-45)	37.3 degrees (15-60)	22.8 degrees (0-50)	21.8 degrees (0-45)

QuickDASH score		ASES score		VAS score		Strength*	
Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop
73.9 (41-86)	48.4 (18.2-77.3)	38.5 (?-?)	60.5 (11.7-81.6)	6.1 (0-10)	2.4 (0-8)	1.8 (1-4)	4 (3-5)

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Conclusion: Although massive proximal humeral bone loss remains a challenge, our early results show that a reverse total shoulder prosthesis using a modular endoprosthetic reconstruction system is a viable option for this problem. Further studies are needed to investigate longevity and longer-term outcomes.

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Computed Tomography and Magnetic Resonance Imaging are Similarly Reliable in the Assessment of Glenohumeral Arthritis and Glenoid Version

ABSTRACT

Background: The purpose of this study was to compare the intra- and inter-observer reliability of CT and T2-weighted MRI for evaluation of the severity of glenoid wear, glenohumeral subluxation, and glenoid version.

Methods: Sixty-one shoulders with primary osteoarthritis had CT and MRI scans before shoulder arthroplasty. All slices were blinded and randomized before evaluation. Two fellowship-trained shoulder surgeons and three orthopaedic surgery trainees reviewed the images to classify glenoid wear (Walch and Mayo classifications) and glenohumeral subluxation (Mayo classification). Glenoid version was measured using Friedman's technique. After a minimum 2-week interval, the process was repeated.

Results: Intraobserver reliability was good for the CT group and fair-to-good for the MRI group for the Walch, Mayo glenoid, and Mayo subluxation classifications; interobserver reliability was poor for the CT and fair-to-poor for the MRI group. For the measurement of glenoid version, intraobserver reliability was good the CT and substantial for the MRI group; interobserver agreement was good for both groups. There were no significant differences in reliability between staff surgeons and trainees for any of the classifications or measurements.

Discussion: CT and MRI appear similarly reliable for the classification of glenohumeral wear patterns. For the measurement of glenoid version, MRI was slightly more reliable than CT within observers. Differences in training level did not produce substantial differences in agreement, suggesting these systems can be applied by observers of different experience levels with similar reliability.

Conclusions: Both CT and/or MRI are reliable as pre-operative planning tools for assessment of glenoid deformity in shoulder arthroplasty.

Level of evidence: Level III, study of diagnostic test

Keywords: shoulder; arthritis; glenoid deformity; evaluation; computed tomography; magnetic resonance imaging; reliability

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Reliability Testing of the Larsen and Sharp Classifications for Rheumatoid Arthritis of the Elbow

ABSTRACT

Background: Two popular systems for classifying rheumatoid arthritis affecting the elbow are the Larsen and Sharp schemes. To our knowledge, no study has investigated the reliability of these 2 systems. We compared the intraobserver and interobserver agreement of the 2 systems to determine whether one is more reliable than the other.

Methods: The radiographs of 45 patients diagnosed with rheumatoid arthritis affecting the elbow were evaluated. Anteroposterior and lateral radiographs were deidentified and distributed to 6 evaluators (4 fellowship-trained upper extremity surgeons and 2 orthopedic trainees). Each evaluator graded all 45 radiographs according to the Larsen and Sharp scoring methods on 2 occasions, at least 2 weeks apart.

Results: Overall intraobserver reliability was 0.93 (95% confidence interval [CI], 0.90-0.95) for the Larsen system and 0.92 (95% CI, 0.86-0.96) for the Sharp classification, both indicating substantial agreement. Overall interobserver reliability was 0.70 (95% CI, 0.60-0.80) for the Larsen classification and 0.68 (95% CI, 0.54-0.81) for the Sharp system, both indicating good agreement. There were no significant differences in the intraobserver or interobserver reliability of the systems overall and no significant differences in reliability between attending surgeons and trainees for either classification system.

Conclusion: The Larsen and Sharp systems both show substantial intraobserver reliability and good interobserver agreement for the radiographic classification of rheumatoid arthritis affecting the elbow. Differences in training level did not result in substantial variances in reliability for either system. We conclude that both systems can be reliably used to evaluate rheumatoid arthritis of the elbow by observers of varying training levels.

Level of evidence: Basic Science Study; Validation of Classification System

Keywords: Elbow; rheumatoid arthritis; classification; radiographic; reliability; severity; progression

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INTRODUCTION

Approximately 50% of patients with rheumatoid arthritis eventually develop involvement of the elbow, which can have a significant effect on the function of the upper extremity.[4,9,10] Plain radiographs are an important part of the initial evaluation of these patients, as well as a means by which to monitor the progression of the disease over time.[14,19] They also are used to monitor the effectiveness of therapy and are an important part of preoperative planning.[6,17,18]

Common radiographic findings in joints affected by rheumatoid arthritis include periarticular osteopenia, erosions, joint space narrowing, soft-tissue swelling, osteoporosis, subluxation and malalignment, ankylosis, and osteophyte formation. Because erosions and joint space narrowing generally are agreed to be the 2 most important findings, they form the basis for most scoring

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systems.[3,19] Numerous radiographic classification methods have been developed to grade the severity of joint involvement. Among these, the Larsen8 and Sharp[14,15] methods are most commonly used. The Sharp method evaluates erosions and joint space narrowing separately, whereas the Larsen scheme grades the global aspect of destruction and includes erosions and joint space narrowing in a single score.[8,15,16,19] Both systems have good interobserver and intraobserver reliability in detecting overall severity and disease progression of rheumatoid arthritis.[2,7,12,13]

Although these systems are commonly used, there are scant data to suggest that one is more reliable than the other for radiographic assessment of the rheumatoid elbow. We pro-posed to evaluate the intraobserver and interobserver reliability of the Larsen and Sharp classification systems for rheumatoid arthritis of the elbow and to determine whether the level of training had an effect on the reliability. We hypothesized that both systems would have acceptable reliability in grading rheumatoid arthritis of the elbow and that higher levels of training would have a positive effect on reliability.

MATERIALS AND METHODS

We identified all patients in our electronic medical record with a diagnosis of rheumatoid arthritis affecting the elbow. Patients with a diagnosis of fracture or those with previous surgical intervention involving implants were excluded, leaving 45 elbows for evaluation. Anteroposterior and lateral radiographs of the affected elbow were obtained using a standardized institutional protocol at the time of initial evaluation. All images were deidentified and randomized into a single file. The images were then independently reviewed by 6 evaluators (4 attending orthopedic surgeons with fellowship training in elbow disorders and 2 orthopedic trainees). The methods of scoring as developed by Larsen[8] **(Table 1)** and Sharp[14,15] **(Table 2)** were included at the beginning of the file to serve as a reference for the evaluators. Each evaluator then scored the radiographs ac-cording to both methods on 2 separate occasions at least 2 weeks apart.

Grade 0	Intact bony outlines and normal joint space
Grade 1	Slight abnormality with periarticular soft-tissue swelling, periarticular osteoporosis, or slight joint space narrowing
Grade 2	Definite abnormality. Erosion is obligatory.
Grade 3	Medium destructive abnormality. Erosion is obligatory.
Grade 4	Severe abnormality where there is usually no joint space left, and the original bony outlines are partly preserved
Grade 5	Mutilating changes, where the original articular surfaces have disappeared

Table 1: Larsen classification[8]

Statistical analysis was performed using AgreeStat 2013.3 soft-ware (Advanced Analytics, LLC. Gaithersburg, MD, USA) and SPSS 22 software (IBM Corp., Armonk, NY, USA). Intraobserver reliability was calculated using Spearman rank correlation coefficients, and interobserver reliability was calculated using the weighted Conger κ. The 95% confidence intervals (CI) were calculated for intraobserver and interobserver agreement as well. Correlation coefficients and κ scores >0.8 were considered to indicate substantial agreement: 0.6 to 0.8, good agreement; 0.4 to 0.6, moderate agreement; and <0.4, fair agreement. Two-tailed t tests were used to evaluate average re-liability figures between scoring systems and between attending surgeons and trainees. Statistical significance was set at $P < .05$.

RESULTS

Overall average intraobserver reliability was 0.93 (95% CI, 0.90-0.95) for the Larsen system and 0.92 (95% CI, 0.86-0.96) for the Sharp classification **(Table 3)**, both indicating substantial agreement. When attending surgeons and trainees were compared, the average Larsen intraobserver reliability was 0.93 for staff and 0.94 for trainees, and the average Sharp intraobserver reliability was 0.92 for staff and 0.95 for trainees. There were no

Joint Space Narrowing Score:	Erosion Score
0=normal	0=normal
1=focal joint narrowing	1=discrete erosions
2=narrowing less than 50% of original joint space	2 to 3=larger erosions according to surface area involved
3=narrowing of more than 50% of original joint space	4=erosions extending over middle of the bone
4=amyloses	5=complete collapse
Total score=Joint Space Narrowing Score + Erosion Score.	

Table 2: Sharp classification[14]

Method	Staff	Trainees	Overall (95% CI)
Larsen Method	0.93	0.94	0.93 (0.90-0.95)
Sharp Method	0.92	0.95	0.92 (0.86-0.92)
CI, confidence interval.			

Table 3: Intraobserver reliability for the Larsen and Sharp classification systems

Method	Staff	Trainees	Overall (95% CI)
Larsen Method	0.70	0.74	0.70 (0.60-0.80)
Sharp Method	0.68	0.67	0.68 (0.54-0.81)
CI, confidence interval.			

Table 4: Interobserver reliability for the Larsen and Sharp classification systems

statistically significant differences in intraobserver reliability between the systems overall or based on training level (P > .05).

Overall interobserver reliability was 0.70 (95% CI, 0.60-0.80) for the Larsen classification and 0.68 (95% CI, 0.54-0.81) for the Sharp system **(Table 4)**, indicating good agreement, and approximately 90% concurrence among evaluators for each system. The Larsen inter-rater reliability was 0.70 for attending surgeons and 0.74 for trainees, and the Sharp inter-rater agreement was 0.68 for staff and 0.67 for trainees. Both systems showed good agreement among evaluators of all training levels. There were no statistically significant differences between the systems for inter-rater reliability overall or between attending surgeons and trainees (P > .05).

DISCUSSION

Radiographs are an integral part of monitoring the severity and progression of rheumatoid arthritis.16,19 Scoring systems have traditionally been applied to a select number of small joints of the wrists, hands, and feet to arrive at a composite score representative of overall joint involvement at a given point. These radiographic scoring systems provide a way to objectively monitor disease progression, and the ability of these systems to assess global radiologic progression of rheumatoid arthritis has been well established.[1,2,5,7,13]

To our knowledge, this is the first study examining the reliability of the Larsen and Sharp methods for grading rheumatoid arthritis when applied specifically to the elbow. We found substantial intrarater reliability and good inter-rater reliability for both systems. Although the difference in reliability of the systems overall was not significant, a smaller variance was seen in the Larsen values compared with the Sharp values. This is likely due to the higher number of options in the Sharp scoring system (0-9) than in the Larsen system (0-5). Intrarater agreement was slightly higher than inter-rater reliability, which is consistent with previous studies.[15-18]

It has been reported that level of training can have an effect on reliability in detecting radiologic progression of rheumatoid arthritis.3 Our study found no significant differences in reliability based on training level when the participants used the Larsen and Sharp systems to grade radiographs. Intraobserver agreement was essentially equivalent between attending surgeons and trainees for both methods, and trainees had good inter-rater agreement with staff evaluators. These findings are consistent with a study in the radiology literature that showed a high correlation between staff radiologists and residents when erosions and joint space narrowing in the hands and wrists were assessed.[11]

We recognize that failure to detect a difference in reliability could be a result of the small number of trainees involved in the study compared with staff. Also, our study did not look at the reliability of detecting progression of disease but only the severity at a single point in time. Although the Larsen and Sharp methods for radiographic evaluation of rheumatoid arthritis were originally proposed to provide a continuous quantitative scale by grading multiple small joints of the hands and wrists,[8,15,19] this study suggests that both systems can be reliably used to assess rheumatoid arthritis of the elbow in isolation from other joints.

One limitation of this study is that although the Larsen and Sharp scoring methods are the most widely used to measure and evaluate changes in rheumatoid arthritis, multiple modifications of each system exist and are used interchangeably.19 The main difference among the modifications of these 2 scoring systems involves the number and location of joints included in the grading, with little variation in the actual method for grading a specific articulation.As such, no standard technique has been universally accepted. In this study, we chose the original Larsen system[8] and the modified Sharp method[13,15] to grade each radiograph because we believed they were most applicable to the elbow. Because both methods showed good reliability, we concluded that evaluating different modifications of these systems would not likely provide additional benefit.

Another limitation of this study is that the radiographic scoring systems analyzed do not take into ac-

count clinical aspects of rheumatoid arthritis, such as pain, swelling, and stiffness. Radiographic findings do not always correlate with clinical presentation, and treatment, therefore, cannot be based on radiographs alone.

CONCLUSION

The Larsen and Sharp systems both show substantial intraobserver reliability and good interobserver agreement for the radiographic classification of rheumatoid arthritis affecting the elbow. Differences in training level did not result in substantial variances in reliability for either system. We conclude that both systems can reliably be used to evaluate rheumatoid arthritis of the elbow by observers of varying training levels.

DISCLAIMER

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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Effect of Chronic Narcotic Use on Episode of Care Outcomes Following Primary Anatomic Total Shoulder Arthroplasty

ABSTRACT

Background: The effect of chronic narcotic use on outcomes of total knee and hip arthroplasty, trauma surgery, rotator cuff surgery, and some spinal surgeries has been investigated; however, there is a paucity of information regarding its effects on early outcomes of anatomic total shoulder arthroplasty (TSA). Further, the evolution of bundled-care payments for TSA may make early outcomes more relevant because these plans typically are tied to a 90-day episode of care. The purpose of this study was to determine the effect of chronic preoperative narcotic use on early post-operative pain relief, narcotic use, length of hospital stay, re-operations, and complications in patients undergoing primary TSA.

Methods: After IRB approval, a database search identified patients undergoing primary anatomic TSA at our institution. Chronic narcotic use was defined as use of narcotic pain medication for a minimum of 3 months prior to surgery. Review of records was completed to determine visual analog scale (VAS) pain scores, length of hospital stay, and complications. Narcotic use was converted to oral morphine equivalents (OME) for in-hospital use, discharge medications, and prescriptions given at 2-, 6-, and 12-week visits. This was complimented by query of a statewide narcotic prescriptions database. Statistical analyses were performed using Fisher's exact test for dichotomous variables and Student's t-test for continuous variables. Differences between groups with $p<0.05$ were considered statistically significant.

Results: Our database search identified 152 patients with primary TSA, 27 in the chronic preoperative narcotic use cohort and 125 without chronic narcotic use. Demographically, there were no statistically significant differences between groups with regard to age, sex, laterality, or body mass index.

Demographics (152 patients)			
	Chronic pain	Nonusers	p
Patients	27	125	-
Age	60.7	63.1	0.25
Sex	11 M / 16 F	74 M / 51 F	0.09
BMI	34.5	32.9	0.30
Side	18 R / 9 L	68 R / 57 L	0.29
Preop VAS	7.0	6.0	0.10

At 2 weeks postoperatively, there was no significant difference in VAS scores between groups (4.7 vs. 3.8, $p = 0.08$); however, at 6 and 12 weeks, chronic narcotic users had significantly higher VAS scores (4.1 vs. 2.3, $p = 0.001$; 2.8 vs. 1.6, $p = 0.02$, respectively). The chronic narcotic use group also had a significantly higher cumulative narcotic requirement (3209 mg vs. 1814 mg, $p = 0.003$).

There was no significant difference between groups (1.4 vs. 1.2 days, $p=0.31$) in length of hospital stay or complication or readmission rates.

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Pain Results			
	Chronic pain	Nonusers	p
VAS			
At 2 weeks	4.7	3.8	0.08
At 6 weeks	4.1	2.3	0.001
At 12 weeks	2.8	1.6	0.02
VAS difference from Pre-op			
At 2 weeks	2.2	2.7	0.81
At 6 weeks	2.8	3.6	0.31
At 12 weeks	4.1	4.5	0.56
Pain Medication (OME)			
Inpatient	172	100	0.02
At 2 weeks	698	253	0.01
At 6 weeks	815	172	0.01
At 12 weeks	404	42	0.03
Total*	3209	1814	0.003
Data available at all intervals (23 chronic, 107 w/o)			

Conclusions: Patients using chronic pre-operative narcotic pain medication had significantly higher VAS scores and narcotic requirements after anatomic TSA, but there were no significant differences between groups regarding length of stay, complication rate, or readmission rate. These results indicate that chronic preoperative narcotic use can be identified as a risk factor for a more difficult post-operative course following TSA compared to that in narcotic-naïve patients. Chronic opoid users, however, do not necessarily require additional peri-operative resources, which is relevant to risk stratification in the emergence of bundled payment programs for TSA.

Secondary Outcomes			
	Chronic pain	Nonusers	p
Length of stay (days)	1.4	1.2	0.31
90-day complication	2	7	0.67
90-day readmission	2	3	0.23
90-day reoperation	0	0	1.00

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Proper Distal Placement of Tibial Nail Improves Rate of Malalignment for Distal Tibial Fractures

ABSTRACT

Objectives: Intramedullary stabilization (IMN) of tibial fractures is associated with improved soft tissue and wound management. However, malalignment is frequently reported after intramedullary nailing of the distal tibia. Although an aberrant proximal start point and trajectory is known to result in malalignment of proximal tibial fractures, appropriate distal nail position when treating distal tibial fractures has not been well described. We hypothesize that the anatomic center of the distal tibia is just lateral and anterior to the center of the distal tibial articular surface in the coronal and sagittal planes respectively, and that placement of the nail along this axis results in improved rates of malalignment when treating distal tibial fractures.

Design: Retrospective study

Level of Evidence: Prognostic Level II

Setting: One level I and one level II trauma center

Patients/Participants: We retrospectively reviewed 203 distal tibial fractures treated with intramedullary nails (primary cohort) whose main fracture line extended within 5 cm of the plafond to evaluate the rate of malalignment with distal nail placement. Additionally, we retrospectively reviewed a secondary cohort of 15 patients with proximal tibial fractures treated with intramedullary nailing for evaluation of passive anatomic distal nail position.

Main Outcome Measures: Primary malalignment ≤ 5 degrees on the AP and Mortise Planes, and ≤ 5 degrees on the Lateral Plane were evaluated in distal tibial fractures on perioperative radiographs.

Results: Primary Cohort: 85 patients met inclusion criteria for evaluation in the coronal plane. Overall malalignment in the coronal plane was 17.6%. There was a 2.9% (1/34) fracture malalignment rate when the nail was placed lateral to the center of the joint versus 27.5% (14/51) when placed medial to the center of the joint, with all occurring in valgus. This achieved statistical significance (p=.04). Correlation was highest when measuring the trajectory on mortise view using the talus as reference point. On the sagittal plane, there was a 44.9% malalignment rate. Malalignment was greatest when the nail was placed in the anterior quadrant 100% (4/4), versus 50% (22/44) in the anterior middle, and 31.3% (5/16) in the posterior middle quadrant. This achieved statistical significance (p=.05).

Secondary Cohort: 15 patients met inclusion criteria for distal nail placement. The mean anatomic distal trajectory of the nail on the coronal plane was 45.2% and 45.5% the width of the tibial plafond and talus, respectively, or just lateral to the center of the joint. On the sagittal plane, anatomic nail placement was 40% the sagittal width of the joint, or just anterior to the center of the joint.

Conclusion: This is the first patient series that defines proper distal tibial nail placement in the treatment of distal tibia fractures. Distal alignment of the nail just lateral to the center of the talus, or along mechanical axis of the tibia, results in significantly improved rates of malalignment on the coronal plane. Fluoroscopic judgment of distal nail trajectory was improved on the mortise view using the talar width as reference. On the sagittal plane, anatomic nail placement is just anterior to the center of the joint. However, non-anatomic nail placement just posterior to the center of the joint had a lower incidence of malalignment.

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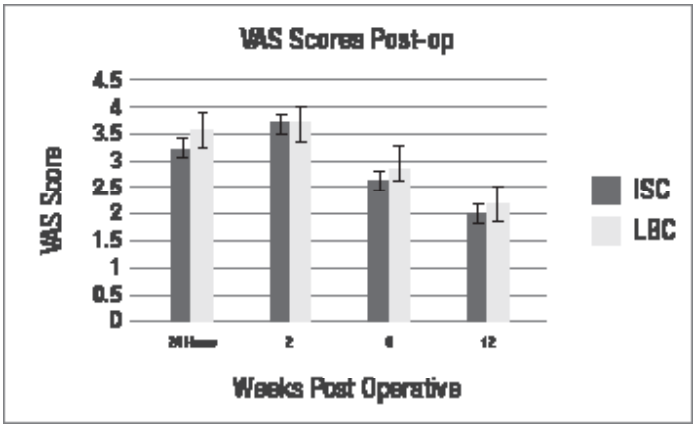
Liposomal Bupivacaine Mixture Has Equivalent Pain Relief and Significantly Fewer Complications at Less Cost than Indwelling Interscalene Catheter in Total Shoulder Arthroplasty

ABSTRACT

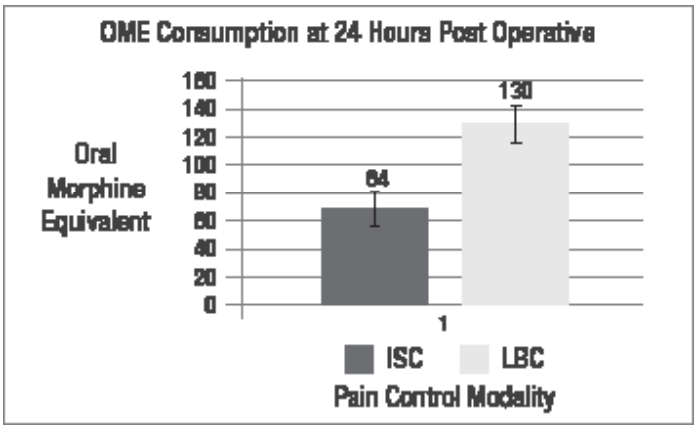
Background: The efficacy and costs of indwelling interscalene catheter (ISC) and liposomal bupivacaine, with and without adjunctive medications, (LBC) in patients with primary shoulder arthroplasty are a source of current debate.

Methods: In 214 arthroplasties, 156 patients had ISC and 58 had LBC injections that were mixed with morphine, ketorolac, and 0.5% bupivacaine with epinephrine. Charts were reviewed for visual analog scale (VAS) pain scores, oral morphine equivalent (OME) usage, major complications, and costs.

Results: VAS scores were not significantly different at 24 hours or at 2, 6, and 12 weeks.



Average OME consumption at 24 hours was significantly more with LBC, but was not significantly different at 12 weeks.



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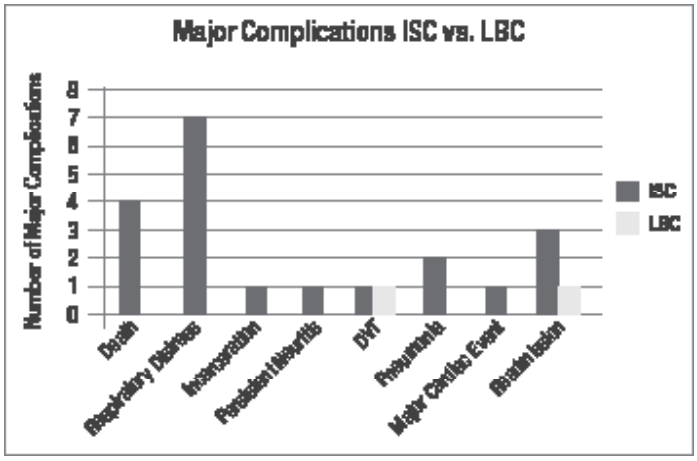
Relative risk of a major complication was nearly 4 times higher with ISC than with LBC.

The average cost for the LBC mixture was $289.04, and for ISC, including equipment and anesthesia fees, was $1559.42.

Conclusion: The intraoperative LBC mixture provided equivalent pain relief with significantly fewer major complications and at markedly lower cost than ISC. LBC required almost twice as much OME to attain the same level of pain relief at 24 hours, but there was no significant difference in the cumulative amount of outpatient narcotic use.



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Ambulatory Surgery Center Hip Arthroplasty is a Safe and More Cost Effective Alternative to the Hospital

ABSTRACT

Background: The current health care environment places an emphasis on implementing cost-control measures while achieving optimal clinical outcomes. The purpose of this study was to evaluate one center's experience with anterior supine intermuscular total hip arthroplasty (ASI THA) performed at an ambulatory surgery center (ASC) and to compare complications and costs to those of the same procedure performed in a hospital setting (HS).

Methods: The charts of 70 patients were reviewed retrospectively; 35 patients with ASI THA performed at an ASC were matched according to medical comorbidities to 35 patients with the same operation performed in a hospital. Operative time, blood loss, length of postoperative stay, complications, and Visual Analog Scale (VAS) pain scores were compared. After obtaining patient consent, costs were derived from insurance explanation-of-benefits documentation and compared between the two groups. Analysis of variance was used to evaluate differences between groups, with $p<0.05$ considered statistically significant.

Results: ASI THA performed in an ASC resulted in a significantly shorter length of postoperative stay (ASC, 13.4 hours; hospital, 38.0 hours; $p <0.0001$) and superior VAS scores at 3 months postoperatively (ASC, 0.4; HS, 0.8; $p =0.03$). There were no significant differences between groups regarding operative time, blood loss, or complications. Costs were significantly different between the two groups (ASC, $29,421; hospital, $41,858) with ASC surgery saving $12,437 over HS procedures ($p <0.0001$).

Conclusions: The ASC group had a shorter length of stay and less postoperative pain, than the HS cohort with no difference in complications. Cost savings were significant, with the ASC group saving an average of $12,437. Further investigation is needed to evaluate longer-term outcomes and cost effectiveness of ASI THA performed on an outpatient basis.

Level of Evidence: Level III, retrospective cohort study

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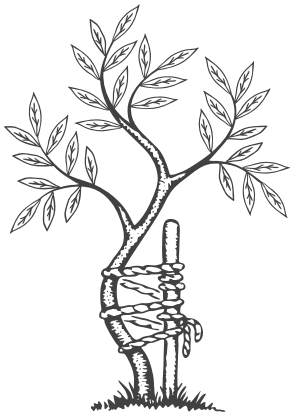

CAMPBELL CLINIC STAFF RESEARCH

Genetic Relationship in a Group of Metal on Metal Total Hip Bearing Failures

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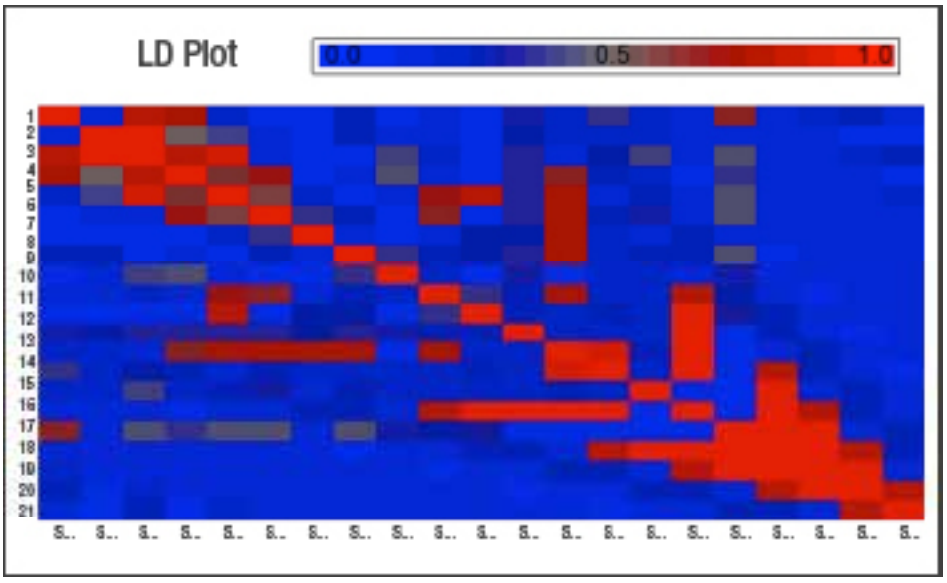
INTRODUCTION: Since the recall of some metal on metal (MoM) THR bearings, surgeons have seen patients with pain, elevated Co and Cr levels and adverse local tissue reactions (ALTR). While many variables may contribute to THR MoM failures, many times these variables are not present in patients who present with symptoms. We investigate the possible genetic predilection of a group of patients who were revised after MoM THR surgery for pain, high Co/Cr levels and ALTR.

METHODS: IRB approval was obtained prior to our study. We have analyzed 19 control (asymptomatic MoM THR patients > 6 years after surgery) and 19 disease (revised MoM THR for high metal ions and ALTR). The 38 sample intensity files were subject to sample Quality Control (QC) using Contrast QC (< 0.4) with an Affymetrix Genotyping Console. The resulting 38 sample files with genotype calls were loaded and further analyzed using the Association Workflow in Partek Genomics Suite 6.6 (Partek, Missouri). Hardy-Weinberg equilibrium test was performed on the single nucleotide polymorphism (SNP) level. The difference between the observed and expected frequencies of each allele at each locus were tested by Fisher's exact test and $\chi 2$ test. To get the working SNP list, two filters were used: (1) a SNP no-call rate should be less than 5%, and (2) minor allele frequency of a SNP should be greater than 5%. After filtering, association analysis of the SNPS with disease was done using Chi2 Test. In this study, $\chi 2$ statistic was used to assess the difference in allele frequencies between the control and disease samples. The value of $\chi 2$ statistic, degrees of freedom, and the associated p-value for each SNP were calculated. Dot Plot was used to visualize the genotypes of all samples.

To measure the non-random association of alleles at different loci, Linkage Disequilibrium analysis was performed using the neighborhood size of 20 and statistic r2. The resulting correlations show the value of r2 for SNPs. The r2 = 1 means that two SNPs are tightly associated.



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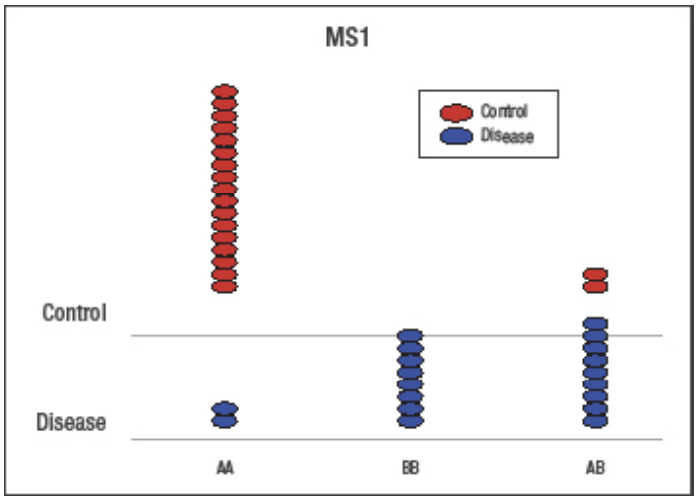
RESULTS: We found that several SNPs are linked to the revision disease group that showed evidence of metal sensitivity. Among them, a strong association in the disease group was found in a SNP called MS1. In the disease group 17/19 patients were either heterozygous or recessive homozygous for MS1, with 17/19 asymptomatic patients were of the homozygous dominant MS1 isoform. Based on the Linkage Disequilibrum analysis results, several other SNPs were also fund to be strongly correlated with the disease group (Fig 1). The controls had an average Co level of 2.4 and Cr level of 1.3 while the disease group 18 and 10.4 respectively.

CONCLUSIONS: This study found a strong genetic relationship in a gene we designate as MS1 where the homozygous recessive and heterozygous isoform genotypes were found in the disease group of revised MoM THRs. A strong correlation of several other SNPs were also found. This may be a good predictor of failures and an avenue for personalized choice of implants in the future.



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Total Hip Arthroplasty Post-Mortem Retrieval Analysis: Does Biologic Response Correlate to Implant Longevity?

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ABSTRACT

Introduction: While failed implants are often studied to determine what may have caused the failure, much can also be learned about what works well by studying well-functioning implants post-mortem. In this study, head dissociation testing, corrosion scoring, polyethylene linear wear measurements, and inflammatory cytokine testing were completed on sixteen well-functioning cadaveric total hip replacements to determine if any correlations exist between wear and corrosion and cytokine presence. These values will be useful as a baseline when reviewing the same criteria for failed implants.

Methods: Cadaveric hemi-pelvises were obtained from two locations, the Medical Education Research Institute (Memphis, TN) and Restore Life USA (Elizabethton, TN). Tissue and synovial fluid samples were obtained and the implant was sent to Drexel University for testing. For head dissociation testing, an Instron 4505 was used with specially-designed head and stem plates to hold the head while the stem was moved down at a set rate (Drexel University, Philadelphia, PA). This testing rig can be seen in **Figure 1**. The experienced load was recorded to determine disassembly force. Corrosion scoring of the male and female taper was performed by three scorers using a semi-quantitative scoring process, where each component was scored 1 (minimal) to 4 (severe). Linear polyethylene wear was measured by identifying the superior and anterior sides, and taking three measurements from each side using a Mitutoyo micrometer (Aurora, IL). These were averaged and subtracted to determine the linear wear of the insert. Synovial fluid was tested for inflammatory cytokine concentrations using the Magnetic Luminex Screening Assay (R&D Systems, Minneapolis, MN). Each of these results were compared to see where correlations may exist.

Figure 1: Head dissociation testing rig.

Results: Usable values were obtained for IL-6, MCP-1, IL-1β, MIP-3α, and M-CSF, while the remaining six cytokines presented values outside of the limits of detection. Disassembly forces ranged from 1430 N to 5370 N, with an average of 2790 ± 1170 N. The average polyethylene wear was 0.183±0.215 mm. Corrosion scores were all minimal or mild for these implants, and were not useful for correlations. The concentrations of each cytokine were plotted against the disassembly force as well as the polyethylene wear. A strong positive correlation was seen between IL-1β and disassembly force (r=0.835, p=0.005). Fairly strong positive correlations were seen between MCP-1 and polyethylene wear as well as

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MIP-3α and polyethylene wear, although these were not considered to be significant (r=0.800 and r=0.642, p>0.05). The correlation coefficients for each comparison can be seen in **Table 1**.

Discussion: The implants used in this testing were well-fixed implants with no signs of osteolysis. Because of this, lower wear and cytokine values are expected. The majority of the implants had values near the lower detection limit of the cytokine, which could explain why not as many significant correlations are seen. There is also a low sample size for some of the comparisons, as two of the implants were not able to be disassembled due to constrained acetabular cups, and some cytokines had one or two samples outside of the limits of detection. Although few significant correlations can be seen in this study, this group of THAs may be useful as a baseline when compared to the same testing of failed implants.

Cytokine	Polyethylene Wear	Disassembly Force
M-CSF	0.392	-0.257
IL-1β	-0.214	0.835
IL-6	0.352	0.483
MCP-1	0.642	-0.036
MIP-3α	0.800	-0.027

Table 1: Correlation coefficients for each comparison

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Do Biomarkers Correlate to Implant Damage Scores in Total Knee Replacements?

ABSTRACT

Introduction: When a primary total knee arthroplasty (TKA) begins to fail, it is difficult to determine whether the inciting reaction is due to metal hypersensitivity, wear-particle induced inflammation, infection, or another unknown cause. This study seeks to compare the concentrations of inflammatory cytokines in synovial fluid collected from cadaveric specimens with TKAs to the femoral component damage score and the polyethylene insert wear score to determine if a correlation exists between the amount of wear and levels of inflammatory cytokines or other biomarkers.

Methods: Twenty cadaveric specimens with primary TKAs were procured from the Medical Education and Research Institute (Memphis, TN) and Restore Life USA (Elizabethton, TN) after obtaining IRB approval. Synovial fluid samples were analyzed using a Magnetic Luminex Screening Assay (R&D Systems) for TNF-α, IL-1β, IL-6, MCP-1, MIP-3α, IL-2 and M-CSF. After retrieval, the implants were sent to Drexel University (Philadelphia, PA) for cleaning and wear scoring. Polyethylene (PE) damage scores were measured for the medial and lateral femoral condyle. Metal damage scoring for the femoral component was performed for the medial and lateral bearing surface as well as for the medial and lateral posterior condylar surface. The total polyethylene wear scores and total femoral damage scores were calculated and ranked. The ranked wear scores were then compared to the ranked cytokine levels. Correlation coefficients and p-values were calculated to determine if there is any significant relationship between cytokine levels and wear scores with an assumed significance of $p < 0.05$.

Results: Examples of severe wear of the PE tibial insert and damaged femoral component are shown in **Figures 1 and 2**. These TKA components were retrieved from the same specimen. The Pearson correlation coefficients and p-values are shown in **Table 1** for both the PE wear scores and the femoral damage scores compared with each inflammatory cytokine. IL-2 and polyethylene wear demonstrated moderate positive correlation, $r = 0.464$. Similarly, IL-2 and femoral damage scores also had a moderate correlation, $r = 0.580$. However, because of the limited sample size for that cytokine, the p-value is insignificant for both comparisons. MCP-1 and femoral damage score demonstrated a moderate positive correlation ($r = 0.473$) with a significant p-value = 0.035. M-CSF and the femoral damage score had a slight positive correlation with a p-value = 0.092.

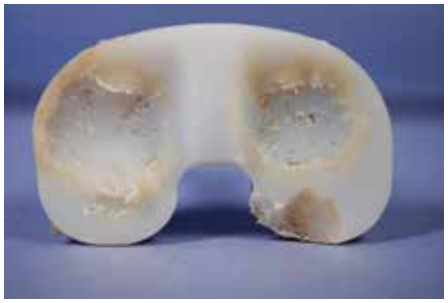

Figure 1: Severe polyethylene wear in tibial insert

Figure 2: Severe femoral component damage

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	Polyethylene Wear		Femoral Damage	
	r	p-value	r	p-value
TNF-α	-0.213	0.48	0.068	0.83
IL-6	-0.170	0.47	-0.223	0.35
MCP-1	0.215	0.36	0.473	0.035
IL-1β	0.289	0.26	-0.254	0.32
MIP-3α	-0.187	0.44	-0.345	0.15
IL-2	0.464	0.35	0.580	0.25
M-CSF	0.191	0.42	0.387	0.092

Table 1: Pearson's correlation coefficients and p-values for comparison between wear and cytokine levels

Conclusion: Overall, none of the inflammatory cytokines showed a statistically significant strong correlation with either the polyethylene wear score or femoral component damage scores. However, these cadaveric TKAs are considered "well-functioning" and are not expected to have significant levels of pro-inflammatory cytokines. As such, these TKAs could be utilized as a baseline for failure analysis comparisons with aseptically loosened implants retrieved at the time of revision surgery. Furthermore, metal ion content analysis of synovial fluid samples may clarify the significance of the role of metal debris in the inflammatory response observed in implant failure.

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Post-Operative Use of the Knee-Walker After Foot and Ankle Surgery, A Retrospective Study

ABSTRACT

Introduction / Purpose: Patients use assistive devices to mobilize during periods of non- or partial- weight bearing after lower extremity surgery or injury. The wheeled knee-walker has grown in popularity, but there is a paucity of literature about this assistive device. The goal of this study was to quantify and describe patient use of knee-walkers after foot and ankle surgery in a group practice of foot and ankle surgeons at multiple sites within a single institution. Primary endpoints included occurrence of falls, frequency of falls, and injury. Secondary endpoints included patient demographics (gender, age, BMI), comorbidities, knee-walker characteristics, duration of use, and satisfaction in this population. This study also attempted to identify any associations between knee-walker-related falls and patient characteristics.

Methods: A retrospective, observational, and descriptive study examined the use of knee-walker after foot and ankle surgery in adult patients. Inclusion criteria were age ≥18 years, unilateral foot or ankle surgery, physician-instructed non-weight bearing status, and having the option of using the knee-walker from March 2015 to April 2016. With institutional review board approval, paper and electronic surveys were sent to 691 patients. Survey data was collected from June 2016 to January 2017. Using the survey, we collected information on knee-walker characteristics, duration of use, payment for the knee-walker, occurrence and frequency of falls, adverse events, and satisfaction and recommendation for or against the use of the knee-walker. Demographic data and comorbidities were obtained from chart review. To determine association between falls and factors collected, Pearson chi-square analysis was used for discrete variables and independent samples T-test for continuous variables.

Results: Eighty-seven of 671 participants responded (13% response rate). Eighty of 87 respondents had demographic data and fully completed surveys, and were therefore included in the study. The average age was 55.6 ± 13.0 years (range: 21 - 85) and average BMI was 30.2 ± 5.9 kg/m2 (range: 18.2 - 48.9). Thirty-five of 80 (44%) participants had ≥3 comorbidities. Most used a steerable, 4-wheeled knee-walker [77 of 80 (96%) steerable, 69 of 80 (87%) 4-wheeled]. Respondents used knee-walkers on average 7.2 ± 5.5 weeks and 4.1 ± 3.9 hours per day. Two-thirds of respondents [53 of 80 (66%)] did not receive instruction on usage of the knee-walker. Thirty-four of 79 (43%) respondents fell while using the knee-walker, and nearly two-thirds [21 of 33 (64%)] of those who fell reported multiple falls. Sixty-eight of 80 (85%) participants were satisfied, 2 of 80 (2.5%) were neutral, and 10 of 80 (13%) were dissatisfied with the knee-walker. Sixteen of 29 (55%) males compared to 18 of 50 (36%) females reported falling ($p = 0.097$). There was no statistical association between falls and age, BMI, comorbidities or being taught to use the knee-walker. Thirty-one of 34 (91%) participants who fell still reported satisfaction with the knee-walker.

Conclusion: To our knowledge, this is the first study reporting on wheeled knee-walker use in a clinical population. A significant portion (43%) of knee-walker users experienced falling, and nearly two-thirds (64%) of those who fell experienced multiple falls. Despite these rates of falling, there were high satisfaction rates overall (85%) and among those who fell (91%). We did not find statistical association between falls and risk factors collected. This institution currently has an ongoing prospective study to examine knee-walker use and characteristics, patient factors, adverse events, and the association between adverse events and possible risk factors.

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Cost Comparison of Operatively Treated Ankle Fractures Managed in an Inpatient Versus Outpatient Setting

ABSTRACT

Introduction: Although choices physicians make profoundly impact the cost of healthcare, few surgeons know actual costs. Without valid cost information, surgeons cannot understand how their choices impact the total cost of care. We leveraged a validated value analytics framework to efficiently allocate clinical care costs to individual patient encounters in an effort to understand the sources and variation of cost of care for a putatively straightforward and common orthopaedic problem.

Methods: We conducted a retrospective cost analysis on all isolated, operatively treated ankle fractures from a Level 1 trauma hospital and affiliated outpatient surgery center between 2013 and 2015. Patients were categorized based on whether they were treated on an inpatient or outpatient basis, and records were reviewed to determine the presence of confounding variables as well as readmission and emergency department (ED) visits within 90 days after surgery. Actual costs were determined using a validated episode of care costing system and analyzed using multivariate regression analysis.

Results: 148 patients (61 inpatients, 87 outpatients) with isolated, operatively treated ankle fractures were included. After controlling for confounding variables, outpatient care was associated with 31.6% (95% CI: 19.8% - 41.8%) lower costs compared to inpatient care. Obese patients had 21.6% (95% CI: 5.8% - 39.8%) higher costs compared to patients who were not obese. There was no difference in reoperation, readmission or return visits to the ED for patients treated on an inpatient or outpatient basis.

Conclusion: Inpatient surgical care is clearly more expensive than outpatient care primarily due to higher facility and labor costs without a clear advantage relative to lower readmission or ER visit rates. Where medically appropriate, this analysis suggests ankle fracture surgery should be provided in an outpatient surgical facility to provide the greatest value to the patient and society.

Level of Evidence: III

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Patient Perceptions and Willingness to Stop Smoking Before Foot and Ankle Surgery: A Preliminary Study

ABSTRACT

Background: The goal of this study was to determine whether patients are aware of the orthopaedic effects of smoking and their level of interest in a supervised smoking cessation program.

Methods: A 5-question survey and short explanation of the deleterious effects of smoking on musculoskeletal healing, focusing on the foot and ankle, were given to each patient who admitted to daily smoking. The survey attempted to determine patients' understanding of smoking and increased risk in foot and ankle surgery.

Results: Among 92 patients surveyed, 52 (57%) indicated that they were unaware of the effects of smoking on wound and bone healing; 79 (86%) answered yes to at least one of the questions regarding interest in a supervised smoking cessation program: 50 (54%) expressed interest regardless of whether surgery was required or not, 25 (27%) expressed interest only if surgery was required for their condition, and 4 showed interest in the smoking cessation program if surgery was required but failed to answer whether they were interested if surgery was not required. Only 13 of the 92 patients (14%) had no interest in a smoking cessation program.

QUESTION	YES	NO
Before reading this information, were you aware that smoking can slow bone and soft-tissue healing and lead to poorer results? (237 responses)	133 (56%)	104 (44%)
Knowing this information, are you more likely to attempt to stop smoking to aid in the healing of your foot or ankle condition? (237 responses)	195 (82%)	42 (18%)
If *surgery is not required* for your condition, would you be agreeable to a supervised smoking cessation program? (195 responses)	124 (64%)	71 (36%)
If *surgery is indicated* for your condition, would you be agreeable to starting a supervised smoking cessation program before surgery? (195 responses)	168 (86%)	27 (14%)
Would you be willing to participate in a smoking cessation program if you knew that your surgery would be postponed until you did? (195 responses)	188 (96%)	7 (4%)

Discussion: Over half of patients were unaware of the effects of smoking on soft-tissue and bone healing, and most expressed interest in a supervised smoking cessation program after learning of these effects. A short discussion followed by referral to a primary care provider and/or smoking cessation hotline is minimally time-consuming and could have significant effects in the health and outcomes of patients with foot and ankle injuries or surgeries.

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Vitamin D Supplementation and Awareness in Patients Presenting to an Orthopaedic Foot and Ankle Clinic

ABSTRACT

Background: Vitamin D deficiency has been implicated in delayed bone healing, stress fractures, and bone pain, but there is limited information about patient awareness of vitamin D. This study was conducted to determine the level of patient awareness of relationship between vitamin D and overall bone health in patients presenting to a foot and ankle clinic.

Methods: New patients presenting to our foot and ankle fellowship-trained staff were asked about vitamin D supplementation and related factors. They also were asked if they were aware that vitamin D deficiency could cause delayed bone healing, stress fractures, and bone pain and whether this information made them more likely to use vitamin D supplements. Patients were contacted at an average of 47 (range, 21 to 81) days after their office visit to determine rates of vitamin D supplementation.

Results: Over a 4-month period, 359 patient questionnaires were collected. At the initial visit 46.8% (166) reported taking some form of vitamin D. Previous diagnoses of vitamin D deficiency and stress fracture were present in 21.1% and 17.4% of patients, respectively. Prior to their visit, 40.2% of patients were aware of the importance of vitamin D for bone health; 79.3% stated the new information made them more likely to take vitamin D supplements. At follow-up 58.1% of 199 patients were taking vitamin D; 43.2% of patients recalled their doctor discussing vitamin D with them.

Conclusion: Awareness of the relationship between vitamin D and overall bone health among patients presenting to a foot and ankle clinic is low (40%). Patients who discuss the importance of vitamin D with their surgeon are more likely to use vitamin D supplements.

Foot and Ankle Patient's Knowledge and Understanding of the Relationship Between Vitamin D and Overall Bone Health

Date of Visit _____

Barcode _____

The American Academy of Orthopaedic Surgeons (AAOS) is currently investigating the effects of Vitamin D on the outcomes of orthopaedic injuries and procedures. Studies have shown that Vitamin D deficiency can cause bone pain, stress fractures, and delayed bone healing. Taking a Vitamin D supplement can improve the chances of a good result of correcting bone problems.

Circle your answer:

1.	Do you currently take a multi-vitamin that contains vitamin D?	Yes	No
2.	Do you currently take vitamin D supplements?	Yes	No
3.	Do you get 20 minutes of sunlight to expose skin daily?	Yes	No
4.	Have you ever been diagnosed with a vitamin D deficiency?	Yes	No
5.	Have you ever been diagnosed with a stress fracture of a bone?	Yes	No
6.	Prior to reading this information, were you aware that vitamin D deficiency could causes bone pain, stress fractures, and delayed bone healing?	Yes	No
7.	Knowing this information, are you more likely to supplement with vitamin D?	Yes	No
8.	Would you be willing to be contacted in 1-2 months to answer for follow-up questions?	Yes	No

If you answered "yes", how would you like to be reached?

1. Phone - please list of the best number to reach you _____
2. Email - please list your email address _____
3. Text - please list number _____

Figure 1: Awareness Survey

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Foot and Ankle Patient's Knowledge and Understanding of the Relationship Between Vitamin D and Overall Bone Health

Date of Survey _____

Barcode Number _____

Method of Follow-up ☐ Phone

☐ Email

☐ Text

These questions are to be answered in regards to your visit with one of the Foot & Ankle Physicians

Did your doctor discuss Vitamin D with you during your recent visit?	Yes	No
Did you receive written materials on Vitamin D?	Yes	No
Are you currently taking Vitamin D?	Yes	No
If yes, how many months have you taking Vitamin D?	_____ months	

Figure 2:
Follow-up Survey

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Orthobiologics: Review of Current Use in the Hand and Wrist*

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INTRODUCTION

Although orthobiologics are not used as frequently in the hand and wrist as in other musculoskeletal sites, they have been found to be useful in several hand and wrist conditions, including Kienböck disease; scaphoid, distal radial, ulnar, and phalangeal fractures and nonunions; osteochondral lesions of the capitate; and thumb arthritis.

The most frequently reported is the use of bone morphogenetic protein for the treatment of Kienböck disease. Animal studies have described improved tendon healing with the use of platelet-rich protein (PRP), but no clinical studies have confirmed these results. PRP has been reported to produce improvements in the outcomes of distal radial fractures and osteoarthritis of the trapeziometacarpal in small numbers of patients. The use of orthobiologics in the hand and wrist has just begun to be explored, and the applications are promising, but clinical trials are necessary to establish efficacy and safety.

ORTHOBIOLOGICS FOR SPECIFIC HAND AND WRIST CONDITIONS

Bone morphogenetic protein (BMP)

Kienböck disease. Jones et al. described improved range of motion, complete resolution of pain, and no further lunate collapse at 6 years after the use of hBMP with vascular pedicle implantation in a patient with stage IIIA Kienböck disease. Rajfer et al. reported arthroscopic curettage and grafting with a mixture of autologous radial cancellous bone marrow graft and BMP-2 in two patients (three wrists) with stage III Kienböck disease, all of which had favorable results.

Fractures/nonunions. Studies of the use of BMP in the treatment of scaphoid nonunions have reached opposing conclusions, with some authors reporting improved healing time and others finding no benefit from the use of BMP-2. Reported complications include heterotopic ossification, persistent nonunion, and loss of range of motion.

Platelet-rich plasma (PRP)

Tendons. Animal studies of the use PRP to improve tendon healing in other upper extremity sites have had varying outcomes. In a study from our institution, autologous blood injection appeared to improve tendon strength and promote a more substantial histological response, while PRP and steroid treatment seemed to weaken tendons while not producing a significant histological improvement. The differences in outcomes of PRP treatment of tendons may be due in large part to the differences in PRP preparation, particularly the concentration of leukocytes.

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Fractures. One recent randomized trial of PRP injections in distal radial fractures, found significant improvements in pain and activity scores in the PRP group but no statistically significant difference in wrist motion.

Osteoarthritis. A study of PRP injection for osteoarthritis found that patients with mild-to-moderate OA had decreased pain and improvements in the DASH and Mayo Wrist scores that persisted at the 6-month follow-up; patients with more severe OA did not experience lasting benefit.

de Quervain tenosynovitis. A single case report described the use of PRP for the treatment of de Quervain tenosynovitis, with a 63% reduction in pain.

Mesenchymal stem cells (MSC)

Most studies of the use of MSCs in structures analogous to the human hand and wrist have been done in animal models. Clinical trials have involved primarily Achilles and patellar tendon injuries, rotator cuff, and tennis elbow.

CONCLUSIONS

Evidence regarding the use of orthobiologics in hand surgery is conflicting. Some animal models show encouraging results, but clinical success has not been well documented. Further research is required to determine the clinical benefit of the various orthobiologics in hand surgery.

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Operative Treatment of Medial Epicondylitis

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EPIDEMIOLOGY AND ETIOLOGY

Medial epicondylitis (golfer's elbow) has an overall prevalence of <1%, but as many as 4% to 8% of individuals may be affected in athletic and occupational settings[6, 19]. Medial epicondylitis is relatively uncommon compared to lateral epicondylitis (tennis elbow), accounting for 10% to 20% of patients with epicondylitis.[4] Most patients with medial epicondylitis are between 40 and 50 years of age, but there is a subset of patients who are younger, usually overhead throwing athletes[1].

The etiology of medial epicondylitis is similar to that of lateral epicondylitis: repetitive supraphysiologic stress that eventually results in microtrauma and tendon degeneration[1]. The principle mechanism of injury is believed to be repetitive eccentric loading of the muscles involved in wrist flexion and forearm pronation combined with valgus overload at the elbow[4].

CLINICAL EXAMINATION

Patients with medial epicondylitis typically complain of persistent medial-sided elbow pain that radiates into the proximal forearm. In overhead throwing, the pain is worst during the late cocking phase and is worst during early acceleration for tennis players or golfers[2]. Thorough physical examination is essential to differentiate medial epicondylitis from other conditions affecting the elbow, such as ulnar neuritis, tendinopathy, ligamentous instability, intra-articular pathology, and trauma. When medial epicondylitis is suspected, other pathologies of the ipsilateral elbow should be sought. Up to 84% of patients with medial epicondylitis related to their occupations have concomitant work-related disorders, such as carpal tunnel, ulnar neuritis, lateral epicondylitis, or rotator cuff tendinitis[6]. Athletes involved in overhead throwing should be evaluated for valgus instability caused by ulnar collateral ligament injury.

RADIOGRAPHIC EVALUATION

Radiographic findings are normal in most patients with medial epicondylitis; however, calcification of the common flexor tendon (CFT) or ulnar collateral ligament (UCL) may be visible in up to 25%[4]. Ultrasonography may be a cost-effective modality for evaluating CFT tendinosis, but is highly operator-dependent[17]. MRI remains the "gold-standard" for radiographic detection of medial epicondylitis as well as other medial elbow pathology[23].

If ulnar neuropathy is suspected, electromyography is indicated.

TREATMENT

Nonoperative treatment

It is important to recognize and treat medial epicondylitis in the acute stage to avoid long-term complications such as chronic pain, loss of func-

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tion, and elbow contracture. Initial treatment of medial epicondylitis is nonoperative and may include rest, NSAIDs, night splinting, and supportive orthoses. These methods are successful in approximately 90% of patients. Studies of extracorporeal shockwave therapy (ESWT) have found varying results[13,16], as have studies of corticosteroid, autologous blood, and PRP injections[20,21]. Physical therapy and rehabilitation remain essential aspects in the nonoperative treatment of medial epicondylitis.

Operative treatment

If a 4- to 6-month aggressive regimen of nonoperative treatment is unsuccessful in relieving symptoms, operative treatment is indicated. Surgical tendon repair generally is considered earlier in elite athletes with definitive tendon disruption as seen on MRI[4] to allow earlier return to sport. The classification system described by Gabel and Morrey is a useful guide for surgical planning[9,10].

Type	Ulnar neuropathy	Operative treatment
IA	None	Epicondylar debridement
IB	Mild symptoms	Debridement with or without cubital tunnel decompression
IIA	Moderate-to-severe symptoms	Decompression of the ulnar nerve
IIB	Moderate-to-severe symptoms	Submuscular transposition of the ulnar nerve

Arthroscopic procedures are not routinely used for medial epicondylitis because of concerns about injury to the medial collateral ligament or the ulnar nerve; however, a cadaver study determined that this risk is low with arthroscopic debridement of the medial epicondyle[25].

Currently, operative treatment of medial epicondylitis most frequently involves (1) excision of the pathologic portion of the tendon, (2) repair of the resulting defect, and (3) firm attachment of any elevated tendon origin back to the epicondyle[4]. Concurrent ulnar nerve of UCL pathology also is treated appropriately. Some authors advocate suture anchor repair of the flexor pronator mass[12], while others prefer repair through bone tunnels. Some studies, however, indicate that medial instability does not develop after common flexor release without reattachment[7].

Cho et al.[3] described a mini-open muscle resection using a 1.5-cm incision at the medial epicondyle to expose the flexor-pronator tendon pathology. Satisfactory results were obtained in 41 (98%) of 42 elbows. Other techniques described for treating medial epicondylitis include fascial elevation and tendon origin resection (FETOR) described by Kwon et al.[15]. They reported significant improvement in pain and strength with no major complications in 22 elbows at 3-year follow-up.

Although Gabel and Morrey[10] recommended ulnar nerve transposition for type IIB medial epicondylitis, considerable evidence exists that there is no difference between simple release and extensive transposition when done as the index procedure for ulnar nerve decompression[5, 8, 11, 14]. If the ulnar nerve is unstable, transposition is indicated.

Outcomes of operative treatment generally correlate with the extent of ulnar neuropathy: types IA and IB have good or excellent results in approximately 95% of patients, while type II involvement has a poorer prognosis[22]. Overall, good outcomes have been reported in 63% [14] to 98%[3] of patients.

CONCLUSION

Nonoperative treatment is successful in over 90% of patients with medial epicondylitis and should be the initial treatment. If symptoms persist after 4 to 6 months of aggressive nonoperative treatment, operative treatment is indicated. Operative treatment may be instituted earlier in younger patients, especially elite athletes involved in overhead throwing sports. Outcomes of operative treatment generally correlate with the extent of ulnar neuropathy and approximately 98% of patients are able to return to work and sports after surgery.

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Biomechanical Evaluation of Two Types of Cephalomedullary Nails in a Proximal Femoral Metastatic Disease Model

ABSTRACT

This biomechanical study tested the relative strengths of two types of cephalomedullary implants (single large proximal locking screw or two smaller proximal locking screws) in a cadaver model simulating metastatic carcinoma of the proximal femur. Standardized defects were reconstructed using a trochanteric antegrade nail with two proximal locking screws or a long intramedullary hip screw with one large proximal locking screw. The primary mode of failure for both groups was proximal screw cut-out. No significant difference was found in stiffness, maximal load-to-failure, or mode of failure between the two types of nails in a model simulating proximal femoral metastatic disease.

INTRODUCTION

Because of the relatively common occurrence of metastases in the proximal femur, as well as the high mechanical stress placed on it during ambulation, the proximal femur is the most common site in the appendicular skeleton to require fixation of an impending or actual pathologic fracture secondary to metastatic carcinoma.[1-8]. Unless managed properly, the morbidity associated with proximal femoral metastatic disease can have a severe impact on a patient's quality of life. As cancer treatment continues to improve, patients with metastatic disease continue to experience longer survival times,[9] making the orthopaedic surgeon's role in helping to preserve quality of life for these patients increasingly important.

Treatment of proximal femoral metastatic disease can be extremely challenging. Fixation must be strong enough to allow immediate full weight-bearing because many patients have a limited life expectancy and should not be subjected to a long postoperative course of limited activity. The fixation also must be durable enough to last for several years because modern treatments of the primary cancer have resulted in longer survival periods for many patients.

A number of studies have described the complexities associated with surgery for metastatic disease of the femur.[1,2,10-19] Most authors agree that prophylactic fixation of impending pathologic fractures is associated with decreased morbidity compared with treatment of complete pathologic fractures,[2-7,15,16,19,20] and most also agree that a cephalomedullary nail is the best device for prophylactic fixation of the femur,[2,5-7,12.15,18,19,21] because of the biomechanical advantages of an intramedullary device over extramedullary devices.[22] Cephalomedullary nails also provide protection of the entire femur with a single device.

Cephalomedullary nails commonly used for fixation of femoral fractures due to metastatic disease have either one large screw or two smaller screws for fixation in the femoral head. Neither design has been proven to be su-

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perior for this indication. This biomechanical study was designed to test the relative strength, stiffness, and mode of failure of a cephalomedullary device with one large lag screw compared with a device with two smaller lag screws produced by the same manufacturer in a cadaver model that simulated metastatic disease of the proximal femur.

MATERIALS AND METHODS

Sixteen matched pairs of human cadaver femurs were used. The first 8 pairs of femurs (University of Tennessee) were harvested from formalin-fixed cadavers and stripped of all soft tissues. Eight additional pairs were obtained as fresh-frozen specimens and contained a minimal amount of soft tissue (Medical Education Research Institute, Memphis, TN). For the formalin-fixed femurs, the average age (± standard deviation) was 62.1±9.03 years. The average age of the fresh-frozen femurs was 63.9±5.25 years. Radiographs were made of each femur to exclude occult pathologic abnormalities.

The fresh-frozen bones were stored at -20°C and slowly thawed to room temperature on the day of modification. In each pair of femurs a Trigen trochanteric antegrade nail (TAN, Smith&Nephew Orthopaedics, Memphis, TN) was placed in a reconstruction mode in either the left or right femur after randomization. A long intramedullary hip screw (IMHS, Smith&Nephew Orthopaedics, Memphis, TN) was placed in the contralateral femur within that pair. All nails were placed with adherence to the technique guide provided by the manufacturer, and an image intensifier was used to ensure proper hardware position. A trochanteric entry portal was used for all nail insertions. Both reconstruction screws and lag screws within the femoral head for both types of nail were advanced centrally to within 5 to 10 mm of the subchondral surface. All nails were rotationally locked with two distal interlocking screws. Nail length was based on the longest nail that could be accommodated in the intramedullary canal between the greater trochanter and the distal physeal scar. All nails were 10 mm in diameter, and the angle between the nail shaft and the proximal screws was 135 degrees.

After placement of each nail, the hardware was removed in a reverse step-wise fashion. Using an oscillating saw, two separate osteotomies were made in the proximal femur to remove the intertrochanteric region **(Fig. 1)**. The first osteotomy extended from the greater trochanter to the lesser trochanter along the basicervical region of the femoral neck. A transverse osteotomy was then made in the proximal femur at the inferior border of the lesser trochanter. Special care was taken to ensure that the defects were symmetrical within a given pair of femurs.

Figure 1: Femoral osteotomies were made after the implant was placed and then removed to ensure proper hardware position.

With the intertrochanteric region removed, the nail and associated hardware were replaced in the remaining bone **(Fig. 2)**. Sterile pre-packaged polymethylmethacrylate (Versabond, Smith and Nephew Orthopaedics, Memphis, TN) was then prepared according to the manufacturer's instructions. Once the polymethylmethacrylate was non-adherent to gloves, the cement was press-fit into the intertrochanteric defect, molded into the contour of the removed bone, and allowed to cure at room temperature **(Fig. 3)**. All 32 femurs were modified in a similar fashion by the same individual and were kept moist with periodic sprays of 0.9% sodium chloride solution during the testing phase.

Figure 2: Implants were then replaced.

Mechanical Testing

Each femur was placed into a rectangular reusable stainless steel fixture. Polymethyl-methacrylate (Versabond, Smith and Nephew Orthopaedics, Memphis, TN) was used to rigidly fix the femur in an anatomical position such that the distal femoral articular surface was horizontal when mounted in the testing apparatus. Additionally, the femur was placed in a neutral position with respect to flexion and ex-

Figure 3: Bone cement was used to fill the defect.

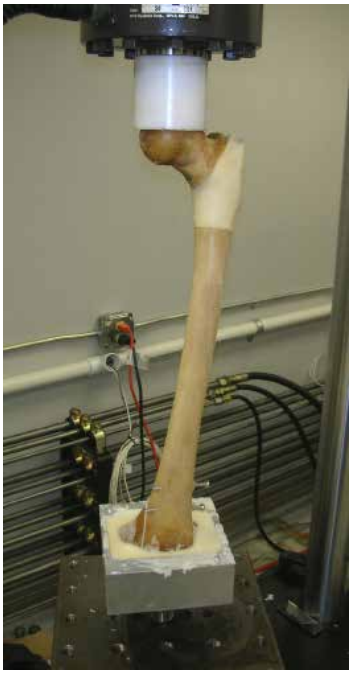

Figure 4: The specimen was placed into the MTS loading frame.

tension. The specimens were mounted onto a MTS loading frame and tested in a pin-pin condition to allow each end to freely pivot **(Fig. 4)**. The femoral head was allowed to freely articulate with a mounted fixture that mimicked an acetabulum. The distal fixture contained a spherical articulation to minimize extraneous bending moments.

Beginning at zero load and displacement, force was applied at a rate of 22 N/second until 2058 N was achieved. Fatigue cycling was then initiated between 206 N and 2058 N at 3 hertz for 2000 cycles. Specimens were observed for any changes or early signs of failure. Each femur that survived the 2000 cycles was then loaded at 22 N/second under load controlled feedback until failure. Failure was defined as a sudden drop in 445 N from the maximally observed load. Load and displacement were recorded by the mechanical testing machine during the complete process, and a resultant load versus displacement curve was plotted. The maximal load to failure and the stiffness were calculated from these graphs.

Statistical Analysis

Two-sided paired t-tests were used to compare results for load to failure and stiffness. All results are based on complete-case analyses, i.e., missing observations were dropped from the analysis data set. The significance level was set at 0.05. All statistical analyses were conducted using R[30].

RESULTS

Five of the 32 femurs did not survive the cycling process. These included 3 formalin-fixed femurs with TAN fixation, 1 formalin-fixed femur with an IMHS, and 1 fresh-frozen femur with a TAN. Stiffness values for these specimens were recorded at the initiation of cycling but not at the end of cycling.

Nail Type	Bone Type	Stiffness (N/cm)	p value
1 screw	Formalin-fixed	4143 ± 2356	0.979
2 screws	Formalin-fixed	4124 ± 1569	
1 screw	Fresh-frozen	4156 ± 755	0.433
2 screws	Fresh-frozen	3765 ± 1066	
1 screw	Combined	4150 ± 1690	0.632
2 screws	Combined	3944 ± 1309	

Table 1: Stiffness at the initiation of cycling

Nail Type	Bone Type	Stiffness (N/cm)	p value
1 screw	Formalin-fixed	4893 ± 1988	0.587
2 screws	Formalin-fixed	5456 ± 2626	
1 screw	Fresh-frozen	4776 ± 1182	0.068
2 screws	Fresh-frozen	3480 ± 1180	
1 screw	Combined	4825 ± 1484	0.379
2 screws	Combined	4303 ± 2074	

Table 2: Stiffness at the end of cycling

Nail Type	Bone Type	Stiffness (N/cm)	p value
1 screw	Formalin-fixed	3693 ± 1360	0.551
2 screws	Formalin-fixed	3844 ± 1631	
1 screw	Fresh-frozen	4375 ± 896	0.066
2 screws	Fresh-frozen	3728 ± 610	
1 screw	Combined	4091 ± 1110	0.181
2 screws	Combined	3776 ± 1083	

Table 3: Maximum Load to Failure

There was no significant difference in the stiffness of the femurs fixed with an IMHS compared to the stiffness of the femurs fixed with a TAN at the beginning of cycling **(Table 1)**. This lack of significant difference held true for the subgroups of femurs as well. Similarly there was no significant difference in the stiffness of the femurs with IMHS compared to the stiffness of the femurs with TANs at the end of cycling **(Table 2)**, nor any significant difference in stiffness at the end of cycling for either of the subgroups. The maximal load to failure for all femurs with IMHS implants was not significantly different from that of all femurs with TANs **(Table 3)**, and there was no significant difference

Figure 5: This specimen failed when the proximal screw cut out through the femoral head.

Figure 6: This specimen failed by proximal screw bending.

in the load to failure for the subgroups. The primary mode of failure was proximal screw cut-out for both IMHS (12 of 16) and TANs (11 of 16). All five of the femurs that did not survive the cycling process failed by proximal screw cut-out **(Fig. 5)**. Three IMHS implants failed by proximal screw bending (two fresh-frozen and one formalin-fixed), and five of the TANs failed by proximal screw bending (3 fresh-frozen and 2 formalin-fixed) **(Fig. 6)**. One IMHS failed by nail bending (fresh-frozen) **(Fig. 7)**.

Figure 7: This specimen failed by nail bending.

DISCUSSION

Most authors agree that cephalomedullary nails are the devices of choice for treatment of metastatic disease of the proximal femur because they provide a mechanical advantage over extramedullary fixation and they provide fixation of the entire femur.[2,5-7,15,18,19,21] There does not appear to be agreement, however, as to which type of nail should be used. Good results have been reported using nails with a single large proximal screw,[2,12,15,18,21] as well as nails with two smaller diameter proximal screws.[5,7,19] While hardware failures in these series were low, it is possible that these failures will become more common as patient survival rates continue to improve. It is important, therefore, to determine if there is an advantage of one type of device over the other.

Several biomechanical studies have demonstrated superiority of intramedullary devices over extramedullary devices in cadaver models of unstable proximal femoral fractures.[15,22,23,24] Biomechanical studies also have demonstrated a mechanical advantage of reconstruction nails with two small screws over nails with a single large proximal screw in models of unstable intertrochanteric fractures[25] and subtrochanteric fractures.[26] A study comparing nails with one large proximal screw to nails with two smaller proximal screws in a finite element model of proximal femoral fractures[27] concluded that nails with two small proximal screws would be more likely to cut out of the femoral head while devices with a single large proximal screw would be more likely to fail through the large hole in the proximal portion of the nail. The authors recommended that the decision of which type of device to use be based on the bone quality of each patient and its potential effect on the most probable mode of failure for that individual. To our knowledge, however, no biomechanical study has been done to try to determine which type of device would be better in a model of metastatic disease of the proximal femur.

Although endoprosthetic reconstruction would be considered for many patients with extensive proximal femoral disease, the femoral modifications for this study were designed to simulate a "worst case" scenario of proximal femoral metastatic disease in which an intramedullary nail would still be a treatment option. Because intramedullary nails generally are recommended for treatment of peritrochanteric disease and cemented hemiarthroplasty is recommended if the femoral head and neck are involved,[3,5,6,20] the head and neck of the femurs were left intact and all of the peritrochanteric bone was resected to create this "worst case" nailing model. The nails were placed and then removed before the femurs were modified so that the resulting nail placement would maintain normal anatomic relationships. Cement was used to fill the defects because this technique has been widely recommended for treating patients with large lesions in this location.[1,3-6,20] The loading configuration was designed to simulate single leg stance in accordance with multiple previous biomechanical studies.[8,26,28] The specimens were cycled between 206 and 2058 N simulating three times body weight for a 70 kg adult.

Both formalin-fixed and fresh-frozen bones were used in this study to represent bones of differing quality. Because formalin fixation has been shown to diminish the energy absorption capacity of cadaver bones,[29] it was thought that this group of specimens might better represent patients with diffuse permeative metastatic disease and the fresh-frozen specimens might better represent patients with isolated lesions of the proximal femur. We expected that the formalin-fixed and fresh-frozen cadaver femurs would have differences in

Figure 8: (A) AP radiograph of the left hip of a 42-year-old man with metastatic carcinoma. The patient complained of severe left hip pain. (B) After fixation with a TAN and bone cement, the patient had immediate pain relief and was able to ambulate full-weight-bearing until he died several months later.

the modes of failure of bones of differing quality, but this was not demonstrated: the primary mode of failure for all groups was proximal screw cut-out, regardless of bone type or fixation type.

As with all biomechanical cadaver bone studies, there are several weakness inherent in the design of this study. While maximal load to failure was used as a testing parameter, fatigue failure is more likely to be the mode of failure in the clinical setting. Increasing the extent of cyclic loading might partially address this problem, but it would be impossible to account for the continual bone remodeling that would occur in the clinical setting. Also, specimens in this study were only loaded axially to simulate single leg stance as described in other studies. The results might be different if other forces were applied to the specimens, such as those resulting from muscular contractions around the hip and those occurring when rising from a seated position. It has been suggested that the benefits of two screws are realized to a greater extent as the force vector moves away form the coronal plane and the screws no longer overlap in line with the applied force.[25] Additionally, the results of this study may not be applicable to similar devices produced by other manufacturers.

Obviously, this study was underpowered, and adding a sufficient number of femurs would have allowed demonstration of a statistically significant difference between the two devices. Despite the criticisms that can be made against performing power analyses at the end of a study that showed no significant differences,[31,32] a post hoc power analysis based on the observed data was conducted to assess just how underpowered this study was. The power analyses demonstrated that between 48 and 525 matched pairs would have been required. Based on analysis of the initial data, it does not appear that the observed differences between devices would be clinically relevant in light of the limitations of a cadaver biomechanical study, and thus, the additional expense of expanding the study could not be justified.

Although not tested in this study, there may be advantages of one implant over the other in specific cases. Reconstruction nails with two small proximal locking screws have a smaller proximal nail diameter than nails with one large proximal screw, which may be an advantage in selected patients because less proximal bone removal is required and the creation of a smaller entry portal may be less traumatic to the hip abductor insertion. In some patients the proximal femur may not be large enough to accept the larger diameter nail. A single-screw nail, on the other hand, may offer the advantage of quicker and easier insertion.

CONCLUSION

In summary, this biomechanical study failed to show a significant difference in stiffness, maximal load to failure, or mode of failure between two types of cephalomedullary nails, one with a single large proximal screw and one with two smaller proximal screws, in a cadaver model simulating metastatic disease of the proximal femur. Both devices have been shown to function well in clinical series, and the choice of implant at this time continues to be based on surgeon preference.

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Bilateral Calcaneonavicular and Talocalcaneal Tarsal Coalitions: Case Reports of Two Patients.

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INTRODUCTION

Tarsal coalition is a rare congenital or acquired anomaly consisting of failure of segmentation of two or more tarsal bones that results in decreased motion. Most tarsal coalitions are congenital, but they can be caused by infection, degenerative joint arthritis, inflammatory arthritis, and clubfoot deformities.[1,2,15] This union or bridging can be fibrous, cartilaginous, or bony. Tarsal coalitions may be present with other orthopaedic disorders such as symphalangism, clinodactyly,[5,10] a great toe shorter than the second toe,[5,26,33] or clubfoot.[5] The incidence of tarsal coalition is most often reported as 1% or less in the general population,[28] but frequencies of 6% to 13% have been reported.[23,32] The true incidence is unknown because many coalitions remain asymptomatic. Coalitions are bilateral in approximately 50% of patients.[2,10]

Multiple tarsal coalitions in one foot and bilateral single coalitions are not uncommon[4,6,7,9,16-18,24,30]; Clarke[7] reported a 20% frequency in 30 patients who had CT evaluations. Bilateral calcaneonavicular and talocalcaneal tarsal coalitions, however, are rare, with only 10 cases reported[1,4,7,12,17,28,35,36].

We describe two patients with bilateral dual calcaneonavicular and talocalcaneal coalitions and report the outcomes of surgical management at long-term follow-up of more than 10 years.

CASE REPORTS

Case 1

An 8-year-old female soccer player sustained a minor twisting injury to her right foot, but she continued to play even though she had pain in her foot. Over the next 24 hours, foot pain rapidly increased, and she was unable to bear weight on the foot. Pain was not relieved with rest and oral over-the-counter analgesics.

On examination she had an antalgic gait on the right, marked tenderness over the right midfoot, particularly over the tarsal navicular bone. She had no other deformity or distal neurovascular deficit. Radiographs of the right foot showed a calcaneonavicular coalition. A short leg-walking cast was worn for 2 weeks for a midfoot sprain. The contralateral foot had decreased subtalar motion, but was asymptomatic. Five months later, she presented with an injury to her left foot. Examination and radiographs identified bilateral calcaneonavicular tarsal coalitions.

Conservative treatment of the right foot was continued with a 3D walking boot and later an ASO ankle brace (Medical Specialities, Charlotte, NC).

At 9 years of age, she continued to have pain and loss of motion in both feet, and repeat radiographs confirmed progression of the coalitions. Computerized tomography (CT) scans confirmed bilateral calaneonavicular coalitions, and identified bilateral middle facet talocalcaneal coalitions. The calcaneonavicular coalitions in both feet were resected first, followed by re-

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Author(s)	Types of coalitions	Patient(s)	Treatment	Outcome
Kendrick[17] 1960	CN, TC	2 males (9-12 years old)	Resection	Not available
Cain & Hyman[4] 1978	CN, TC	13-year-old male	Medial calcaneal closing-wedge osteotomy	Pain-free, returned to normal activities, including sports, at 9-year follow-up
Wheeler et al.[35] 1981	CN, TC	15.5-year-old male	Triple arthrodesis	Normal gait, pain-free
Wiles et al.[36] 1989	CN, TC	34-year-old male	CN resection, R foot, 14 months earlier	Presented with pain and swelling R foot
Clarke[7] 1997	CN, TC, TN	9-year-old female	Resection	Asymptomatic at 9-month FU Minimal symptoms at age 14
	TN, TC	5-year-old female	TC lateral closing wedge osteotomy (R)	Intermittent pain at 2 years
Bhalaik et al.[1] 2002	CN, TC	13-year-old male	NWB cast X 6 weeks	Pain-free at 2-year follow-up
Goldcher[12] 2008	CN, TC, TN	52-year-old female	Footwear and plantar orthosis	Pain-free at 18 months
Pino et al.[28] 2013	CN, TC	15-year-old male	Resection – left foot	Asymptomatic

CN, calcaneonavicular; TC, talocalcaneal; TN, talonavicular

Reported bilateral multiple coalitions

section of the talocalcaneal coalitions 3 months later. After 2 weeks in lower-leg casts, she was placed in bilateral 3D boots and physical therapy was begun. Seven months after surgery, she returned to playing sports with no pain **(Figure 1)**.

At 2.4 years after surgery, her left foot was doing well, but she had intermittent pain in the right foot. At this stage, her activities were modified to include non-impact sports such as swimming and diving. At 14 years of age, 4.5 years after surgery, she continued to participate in sports, but complained of diffuse pain in both feet, worse on the right side. Six months of rehabilitation and restricted sports activities did not relieve her symptoms, and repeat CT scans showed bilateral residual calcaneonavicular coalitions, and repeat resections of the were done. She was symptom-free for the next 3 years, but then she complained of pain along the calcaneal incisions.

Figure 1: Post-op image following resection of calcaneo-navicular coalition.

At 10.5 years after her first surgery, her symptoms recurred following a 5K run. Radiographs of both feet showed an adequate resection at the site of the previous calcaneonavicular coalition resections and fusion of the talocalcaneal coalitions. The option of arthrodesis to relieve pain was discussed with the patient and family.

Case 2

A 14-year-old male student reported bilateral foot pain of 18 months' duration which worsened with long walks, particularly on uneven surfaces. He had no history of trauma, and shoe modifications had not provided any pain relief.

On examination, he had no antalgic gait or any bilateral calf or quadriceps atrophy. He had bilateral pes planus on standing and complained of tenderness along the anterolateral border of both feet. Subtalar joint motion was decreased bilaterally. CT scan was suggestive of bilateral middle facet tarsal coalitions, partially ossified on right and fibrocartilaginous on the left, along with bilateral calcaneonavicular coalitions.

Both calcaneonavicular tarsal coalitions were resected initially, followed by resection of the talocalcaneal coalitions 2 months later. His recovery was excellent; although he had pes planus and 50% motion of his subtalar joints bilaterally, he began playing soccer again. He was followed with annual checkups for 3 years. At 26 years of age, 12 years after his surgery, he is symptom-free except for occasional pain over the lateral border of the right foot. He had approximately 50% of subtalar range of motion on the right and about 70% of subtalar motion on the left. When standing on his toes, he corrected into heel varus on the left side and to neutral on the right **(Figure 2)**.

His radiographs demonstrated normal articular sur-

faces of the subtalar, talonavicular, and calcaneocuboid joints.

DISCUSSION

Although multiple coalitions in the same foot are not uncommon,[4,6,7,9,16-18,24,30] bilateral multiple coalitions are rare, with only 10 cases reported[1,4,7,12,17,28,35,36]. Whether unilateral or bilateral, the presence of multiple coalitions may jeopardize surgical outcomes if not recognized and treated.[6,8,9,37] Cowell,[9] in his study of resections of 46 calcaneonavicular coalitions, reported 3 failures due to concurrent talocalcaneal coalitions, and Wiles et al.[37] described failed calcaneonavicular bar resection in a patient with a concurrent talocalcaneal coalition. Charles et al.[6] described a patient with cavovarus deformities attributed to tarsal coalitions: talocalcaneal coalition in the left foot, talocalcaneal and calcaneonavicular coalitions in the right. The presence of dual coalitions seemed to significantly affect the progression and severity of the foot deformity.

Figure 2: Toe rise exam reveals persistent hindfoot valgus on the right foot.

All patients with suspected tarsal coalitions should be evaluated with a series of radiographs including anterior-posterior, lateral, 45-degree oblique, and Harris axial views of the foot. Calcaneonavicular coalitions usually are visible on the oblique view, while talocalcaneal coalitions of the middle and posterior facets are visible on the Harris axial view. Characteristic radiographic features of middle facet tarsal coalitions include obliteration of the joint with destruction of the cortical plate of the subtalar joint, talar beaking, broadening of the lateral process of the calcaneus, and a radiographic "C" sign formed by the medial outline of the talar dome and the inferior outline of the sustentaculum tali.[3,15,21,34]

If plain radiographs are non-conclusive, axial computed tomography (CT) can help identify a coalition and determine if it is osseous, cartilaginous, or fibrous. Three-dimension (3D) reconstruction is useful in selected cases for precise location, shape, and nature of the coalition, information that is helpful forplanning resection.[31] Magnetic resonance imaging (MRI) can be used to delineate coalitions, especially early fibrous ones, and has a high correlation with CT, although CT generally is less expensive.[11]

Calcaneonavicular and talocalcaneal tarsal coalitions may be initially treated with casting or an orthosis. Use of arch supports and other foot supports or 6 weeks of casting may be effective,[8,9,20] but nonsurgical treatment rarely allows return to the patient's previous activity level.[2,14,22] The natural history of tarsal coalitions is a progressive loss of motion over time, although the speed of the progression is unpredictable. If pain persists and the middle facet coalition is less than 50% bony, resection of the coalition, with or without interposition of tendon or fat, is indicated to try to prevent further loss of motion and preserve the motion that is present.[13,25,27] If the coalition is more 50% bony or if resection does not relieve symptoms and severe degenerative changes are present, subtler triple arthrodesis may be a better option.[19]

After conservative treatment was unsuccessful in relieving symptoms, both of our patients had bilateral resections of both coalitions. Because of their young age, the lack of degeneration of the articular cartilage, and the amount of motion present, resection was chosen over osteotomy and arthrodesis. The 8-year-old girl required a second resection of the calcaneonavicular coalitions because of continued pain and persistence of the coalitions in both feet. Although not completely symptom-free at any time, she did have complete relief of pain for 3 years after revision resection. Her symptoms recurred and were severe enough at 10-year follow-up that triple arthrodesis is being considered. The 14-year-old boy remained symptom-free and at 12 years after surgery was able to participate in competitive sports.

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Football-related concussion and lower extremity injuries: have rule changes in the NFL an NCAA had any effect on younger participants?

Objective: The objective of this study was to determine if recent changes in the rules regarding tackling techniques at professional and collegiate levels have had an effect on the number of concussions and lower extremity injuries football players between the ages of 6 and 18 years.

Methods: A stratified probability sample obtained from the National Electronic Injury Surveillance System of U.S. hospitals providing emergency services for the years 2006, 2009, and 2012 was used. Codes for all football-related injuries in patients between the ages of 6 to 18 years were analyzed.

Results: An estimated 351,408 football-related emergency department visits were reported in 2006, 338,278 in 2009, and 360,468 in 2012. The estimated numbers of emergency department visits for football-related concussions were 12,238 (3%), 16,768 (5%), and 27,933 (8%), respectively. The estimated numbers of emergency room visits for lower extremity football injuries were 91,184 (26%), 86,957 (26%), and 89,971 (25%), respectively.

Conclusion: Changes in the rules and tactics of the game at professional and collegiate levels appear to have had little effect on decreasing the frequency of concussions in young players. An increased awareness may have led to more frequent diagnosis and reporting of concussions in pediatric athletes, but the two-fold increase in concussions in 2012 compared to 2006 is a strong indication that these injuries remain a significant risk in this group of young athletes. Our study also did not show an increase in lower extremity injuries after the change in rules, with these numbers remaining fairly constant.

Key words: pediatric, youth sports, head injury, fracture, risk

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INTRODUCTION

Football is a popular sport among America's youth, with numerous programs for players as young as 6 years through high school, college, and professional levels.[1,2] The number of young athletes participating in football varies according to the source. Wong et al.[3] reported that football players between the ages of 7 and 14 years make up about 70% of all football players, with 3.5 million participants, while organized youth football leagues, such as Pop Warner, report approximately 250,000 participants between the ages 5 to 16 years and up to approximately 600,000 youth football players in 2013.[4,5] Because of the fast pace and aggressive nature of the game, injuries are common. An overall estimated 1.2 million football-related injuries per year for all age groups are reported.[1,2]

Rising concerns about concussions in football and growing evidence that repeated concussions may increase an athlete's risk for chronic traumatic encephalopathy and mental health issues, such as dementia, Parkinson disease, and depression in later life,[6-13] have lead to recent changes in rules and tackling tactics by the National Football League (NFL) and other sports governing authorities.[14-18] Largely as a result of the 2009 Congressional Hearings on concussions in the NFL, multiple rules changes have been adopted by the NFL and the National Collegiate Athletic Association (NCAA) in an effort to protect players from head and neck trauma[19,20] These rule changes have

increased in complexity and scope from 2008 through 2012. Rule changes include moving the kick-off to the 35-yard line to shorten the distance between opposing players and decrease the frequency of violent collisions during run-backs; banning the hitting of "defenseless" players in the head or neck area with the helmet, facemask, forearm, or shoulder; and penalizing players who launch themselves forward and upward into their opponents delivering a blow to the opponents' helmet with any part of their own helmet.[19,20] Some have suggested that because of concerns about hitting too high, tacklers aiming lower may cause an increased number of lower extremity injuries. These changes in rules and tactics at professional and collegiate levels also have been instituted in some form at high school and youth levels; however, it is unclear if they have been effective in preventing head injuries or if they have been the cause of increased lower extremity injuries in these young athletes.

With more participation in youth football, injuries related to the sport continue to rise.[1,2] Many of the injuries seen at the professional level are also seen at the youth, high school and collegiate levels.[2] The rate of injury per 1000 athlete exposures during games has been reported to be 17.3.1 Running backs and linebackers are reported to have the highest rates of injury at the college level. Tackling or being tackled causes most of the injuries.[1] Running plays also account for most concussions and season-ending injuries.

The main purpose of this study was to determine the estimated number of emergency department visits for football-related concussions and lower-extremity injuries in players 6 to 18 years of age at three time points (2006, 2009, and 2012) and to note any changes in the frequencies of injuries. We hypothesized that with the recently introduced changes in tactics and rules to prevent concussions and head injuries,[19-21] the number of concussions would be lower but the number of lower extremity injuries would be higher.

MATERIALS AND METHODS

This study was based on a freely available, de-identified nationwide database and, therefore, was exempt from institutional review board approval. The NEISS is an injury surveillance system operated by the United States Consumer Product Safety Commission; it gathers data from approximately 100 hospitals selected as a probability sample. The probabilty sample is obtained by dividing the entire population into different subgroups or strata then randomly selecting the final subjects proportionally from the different strata of all 6100 United States hospitals that have a minimum of 6 beds with a 24-hour emergency department then extrapolating or estimating national numbers for the entire United States.[22,23] The football-related injury code used was 1211, the code for concussion was 52, and the codes for lower extremity injuries were 35 (knee), 36 (lower leg), 37 (ankle), 81 (upper leg), 83 (foot) and 93 (toe).

Data were collected on football-related concussions and lower extremity injuries in children 6 to 18 years of age treated in emergency departments in 2006, 2009, and 2012. Database spreadsheets used were independent database spreadsheets obtained from NEISS website for individual years, with estimates calculated using SAS software version 9.3, BASE (SAS Institute Inc., Cary, NC, USA [2010]) and the stratified sampling analysis methods. No specific inclusion or exclusion criteria were needed because the information was obtained by running codes for the age group 6 to 18 years. All estimates were included.

Variables studied were emergency department visits related to concussions, lower extremity injuries, age, sex, type of football game (organized or school sports).

Statistical analysis

A Z-test was used for all comparisons of estimates among variables and years. A P value of < 0.05 was considered statistically significant.

Year	ED visits for football injuries	Mean age in years	ED visits for football-related concussions	ED visits for football-related lower extremity injuries	Males	Females
2006	351,408	13.39	12,238 (4%)	91,184 (26%)	95%	5%
2009	338, 278	13.36	16,768 (5%)	86,957 (26%)	95%	5%
2012	360,468	13.17	27,933 (8%)	89,971 (25%)	95%	5%

ED, emergency department

Table 1: Emergency department visits for football-related injuries in players 6 to 18 years of age for years 2006, 2009 and 2012.

Football-related concussions			
Year	School	Organized sports	Others
2006	39%	52%	9%
2009	32%	54%	14%
2012	27%	52%	21%
Football-related lower extremity injuries			
Year	School	Organized sports	Others
2006	33%	41%	26%
2009	26%	49%	25%
2012	25%	46%	29%

Table 2: Frequency of football-related concussion and lower extremity injuries in school and organized sports for years 2006, 2009 and 2012.

RESULTS

During the study years, the estimated number of emergency room visits for all football-related injuries as well as the age of the patients remained relatively constant. However, the estimated number of emergency room visits for football-related concussions in 2012 (27,933) was double that in 2006 (12,238), a statistically significant increase ($P < 0.001$). There was no significant difference among the number of estimated emergency department visits (91,184 in year 2006, 86,957 in year 2009, and 89,971 in year 2012) for football-related lower-extremity injuries at any time point **(Table 1)**. Although fractures (any part of the body) made up only 21% to 26 of all injuries, 16 % to 20% of lower-extremity injuries were fractures.

In all three years, 95% to 96% of football-related injuries, including concussions and lower-extremity injuries, were in boys. Distribution of injuries as to place of occurrence and type of sports participation is shown in **Table 2**. Places of occurrence were grouped as school, organized sports, and others (farm, home, public place, street, unknown).

Subgroup analysis among prepubertal (elementary school, 6-10 years), middle school (early post-puberty, 11-14 years), and high school (late puberty, 15-18 years) age groups revealed that age group 11-14 years had the highest emergency department visits for football-related lower extremity fractures. Interestingly, the age group 11-14 years also had a striking and statistically significant increase ($P < 0.05$) in emergency department visits for football-related concussions in 2012 compared to 2006 **(Table 3)**.

DISCUSSION

Concerns about frequent concussions in football[7,12,15,24-27] and their long-term consequences on health have resulted in changes in the rules and tactics of the game.[19-21] Although numerous studies have explored injuries and health problems frequently seen in professional football players,[7,8,15,28-34] we are not aware of any nationwide study in the 6 to 18-year age group that identified changes in football-related concussions or lower extremity injury after these rule changes were instituted.

Our study showed that after implementation of the new rules and tactics at professional and collegiate levels of play since 2008 overall football injuries have remained fairly constant in the 6 to 18-year age group (average 13 to 14 years), with no statistical differences noted, including injuries of the lower extremity. However, during that same time period, the percentage of concussions doubled from 4% to 8% of total injuries.

The Centers for Disease Control and Prevention have labeled sports-related concussions an "epidemic" (CDC website). Long recognized as a risk in professional football, high rates of concussions have been documented in college and high-school football players: 9% to 13% of all injuries in high-school players[27,35] and 8% of inju-

Age group in years	Year	Concussions (% of total football related ED visits estimate)	Lower extremity fractures (% of total football related ED visits estimate)
6-10	2006	606 (0.1%)	2335 (0.6%)
	2009	1824 (0.5%)	2164 (0.6%)
	2012	3317 (0.9%)	1991 (0.5%)
11-14	2006	4751 (1.3%)	9920 (2.8%)
	2009	5667 (1.6%)	8878 (2.6%)
	2012	13517 (3.7%)*	7368 (2.0%)
15-18	2006	6881 (1.9%)	6297 (1.7%)
	2009	9277 (2.7%)	6513 (1.9%)
	2012	11100 (3.0%)	5339 (1.4%)
Total	2006	12238 (3. 5)	18551 (5.2%)
	2009	16768 (4.9%)	17555 (5.1%)
	2012	27933 (7.7%)*	14698 (4.0%)

**- Statistically significant difference when compared to the respective estimate for year 2006. ED, emergency department.*

Table 3: Distribution of injuries for different age groups.

ries in collegiate players.[36] A more recent study of 468 youth football players found a comparable injury rate in football players between the ages of 8 to 12 years.[26] In an earlier study, Nation et al.[33] reported that an estimated 5,252,721 children and adolescents 6 to 17 years old were treated in emergency departments for football-related injuries between 1990 and 2007, with the annual number of visits increasing by 26.5% over the 18-year study period. The 12- to 17-year-old age group accounted for 78% of all injuries and had nearly twice the odds of sustaining a concussion. Lykissas et al.,[37] in their study on trends in pediatric sports- and recreation-related injuries in United States over the last decade, found that football injuries have increased by 22.8% overall over the last decade (2010 compared to 2001) for this age group, and they noted an increasing trend of concussive injuries from 4,138 in 2000 to 10,759 in 2010.

Concerns about football-related concussions have produced attempts to decrease the frequency of these injuries, resulting in changes in game rules and tactics, primarily focusing on lower body tackling to avoid "hits" to the upper body and head.[19-21] Changes first instituted by the NFL have been adopted by college, high-school, and youth teams. Recognizing the need to teach proper technique early, the NFL made a $45 million grant to expand the Heads Up Football program for youth football players. It appears, however, from our study that these measures have not decreased the frequency of concussions in youth football **(Figure 1)**. The increase noted in our study may be due to increased reporting. Thus, it is difficult to interpret from the results of this study whether this increase is a true increase or simply an increase in reporting because of increased awareness. The NFL injury report also reported a significant increase in concussions in NFL players in 2015 over the previous year.[38] What is certain is that these changes in rules have not decreased concussion injuries in this sport.

In regard to lower extremity trauma related to football, Lykiss et al.[37] reported an increased frequency over the last decade in the 5 to 14-year age group. With the increased emphasis on lower body tackling, we thought lower extremity injuries would also increase; however, our study showed otherwise, with lower extremity injuries remaining constant over the study period.

Limitations of the study are related to the use of the

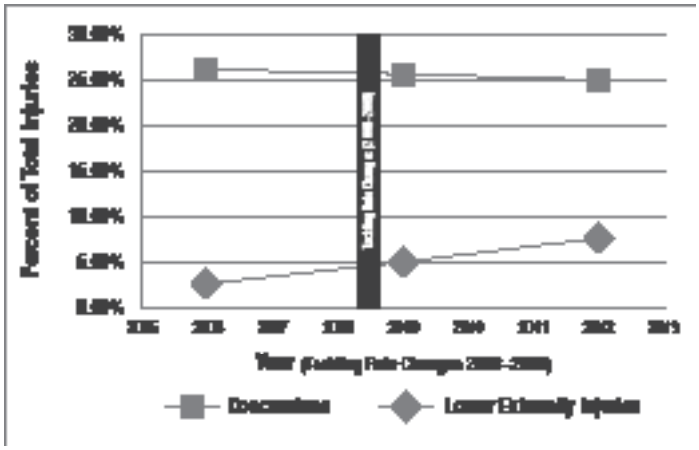

Figure 1: Football-related concussions and lower extremity injuries from 2006-2012, before and after tackling rule changes.

NEISS database. The database may underestimate the actual number of injuries in this patient population, because only injuries treated in an emergency department are included and those treated in non-emergency health care facilities, such as private physician offices or urgent care centers, are not recorded in the database. Nevertheless, this should be common for all three time points and, therefore, should not have affected our statistical comparison overall. The database also lacks information related to the mechanism of injury, the degree of athletic exposure, the skill being attempted at the time of injury, the setting (practice, competition, or recreation), the type of supervision at the time of injury, the number of days of activity lost, and the ultimate outcome. The NEISS data reflect only the most severe injury at the time of presentation, which may underestimate the number of minor injuries.

CONCLUSION

The increase in the frequency of concussions in youth football players may have two possible explanations. Either the changes in rules at the collegiate and professional levels have, thus far, had no effect on the rates of concussions in the pediatric population or the emphasis on head trauma at the NFL and college levels has lead to an increased awareness and diagnosis of these injuries. The increase in the frequency of ED visits for concussions coupled with the relatively constant frequency of lower extremity injuries suggests that concussions are still on rise in this sport and further interventions are needed to help reduce their occurrence.

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In Utero Gunshot Wound Resulting in Permanent Neurologic Deficit: Case Report

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INTRODUCTION

Mortality of the fetus following a penetrating gunshot wound is high, estimated in the range of 47% to 71%.[1,2,4-6] Two published accounts have described in utero gunshot wounds in which the fetus survived and sustained an initial neurologic insult but had no permanent neurologic deficits at follow up.[3,7] We present a case of a fetus that sustained a permanent spinal cord injury following an accidental gunshot wound to the mother. To our knowledge, this is the first reported case of this type of injury in the English literature.

CASE REPORT

A 17-year-old (gravida 1 para 0) African-American female with a 35-week gestation pregnancy arrived in the emergency department after receiving an accidental gunshot to the abdomen. The mother sustained a through-and-through gunshot wound to the left uterine fundus. Prior to this incident, the mother had received routine prenatal care and was experiencing an uneventful pregnancy. An emergency cesarean section and exploratory laparotomy with small bowel anastomosis were performed, after which the mother's hospital course was routine and she was discharged home 5 days after surgery with no noted complications.

Her 2449 g fetus was delivered during the exploratory laparotomy and emergency cesarean section due to fetal bradycardia as low as 60 bpm. The newborn had 1- and 5-minute Apgar scores of 5 and 9, respectively. Initial fetal cord gasses revealed a venous pH level of 7.04 and an arterial pH level of 6.97, indicating fetal metabolic acidosis secondary to the gunshot wound. Lower extremity hypotonia was noted on initial examination. The infant was initially hypotensive, but responded to two 10 cc/kg boluses of normal saline and a transfusion of 15 cc/kg packed red blood cells. Physical examination of the infant revealed a through-and-through gunshot wound with entry near the right anterior abdomen and iliac wing. Plain film radiographs showed no ballistic fragments in the abdomen and a questionable fracture at L1. The infant had blood in the mouth and urethral meatus as well as meconium draining from the entrance wound. Because of increased periods of apnea and hypotonia, the infant was intubated and transferred to the newborn intensive care unit of the adult trauma center to which the mother initially presented. Penicillin and gentamycin antibiotic prophylaxis was initiated soon after birth.

Pediatric general surgery and pediatric orthopaedic specialists were consulted. An initial orthopaedic consult was obtained 1.5 hours after delivery. At the request of general surgery, the infant was transferred from the adult trauma center to the local children's hospital neonatal intensive care unit. A Foley catheter and nasogastric tube were inserted. The infant was taken

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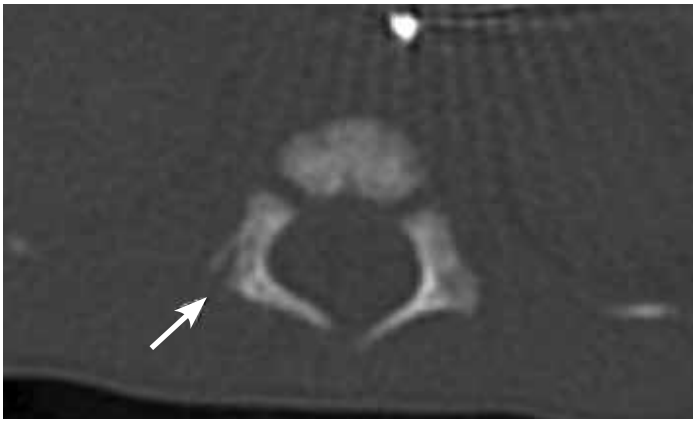
urgently to the operating room at the children's hospital. During the exploratory laparotomy, the infant was noted to have an injury to the colon that was repaired with ileocolectomy and iliocolonic anastomosis. The remaining intraabdominal contents were within normal limits except for a contusion to the right kidney. Intraoperative urology consultation determined that the ureter was intact and that no surgical intervention was required for the renal contusion.

Orthopaedic examination of the infant in the post-anesthesia care unit revealed a small, repaired entrance wound about the right iliac crest and a small exit wound at the T8-T9 level posteriorly. Upper extremity examination was within normal limits. The pelvis was stable. Femoral and pedal pulses were palpable and strong. The infant had full passive range of motion of the hips, knees, and ankles. No spontaneous movement of lower extremities was elicited, and the infant was not responding to light touch or pinch. Radiographs of the lumbar spine and pelvis showed a possible fracture at L1. Post-operative computerized tomography (CT) scan of the abdomen, pelvis, and thoracic spine revealed right renal cortical injury with mild to moderate right perirenal hematoma and a drain in the right paracolic gutter after ileocecectomy with ileocolonic anastomosis. There was minimal free intraperitoneal air and edema in the right anterior abdominal wall, but no other soft-organ injury and no free fluid were noted. Nondisplaced fractures of L1 and L2 pedicles and transverse processes on the right were identified, with no evidence of intraspinal injury.



Axial CT scan of L1 vertebral level shows fracture of the pedicle sustained in gunshot wound.

Postoperative magnetic resonance imaging (MRI) showed no cord compression or evidence of spinal cord injury. Ultrasound of the spine revealed focal edema in the spinal cord at the level of L1 with extraaxial hematoma on the right displacing the spinal cord to the left, but without evidence of significant cord compression. Percussive injury to the paraspinous muscles was suspected.

The infant was extubated to room air on the third day. No further episodes of apnea were noted. On day 6, minimal movement was first noted in left lower extremity but still no movement in the right. Follow-up renal ultrasound on day 7 revealed improvement in renal contusion. The Foley catheter was removed and in-and-out catheterizations were started secondary to a neurogenic bladder. Spontaneous urination was noted on day 8; therefore, in-and-out catheterizations were discontinued. Intravenous total parenteral nutrition (TPN) was started on the third day and oral feeds were started at 9 days after decreased drainage was noted from the nasogastric tube. Feeds were advanced over the next 4 weeks and were well tolerated. There were no further surgical interventions, and the infant was discharged home at 5 weeks of age. At discharge, the infant was flaccid in the right lower extremity. The infant was followed by the urology service for a neurogenic bladder secondary to the spinal cord injury. He was also followed by general surgery to ensure proper weight gain. He did not require any other non-orthopaedic surgeries following initial discharge from the children's hospital.

The infant presented to the orthopaedic clinic at 2 months of age for follow-up with a developing plantar-flexion contracture of his right foot. Examination revealed intact gross motor function to his left lower extremity, but he had a flaccid right lower extremity, with the exception of 1/5 hip flexion. He also had mild right heel cord tightness and a flexion contracture of the flexor hallucis longus. The flexion contractures were correctable to the neutral position. The family was given instruction on home stretching exercises, and an ankle-foot orthosis was prescribed.

At 2 years of age, despite the bracing and stretching, the child had developed a fixed Achilles contracture of his right lower extremity, and a persistent motor deficit existed. His left lower extremity demonstrated good hip and knee function, but there was an absence of toe flexion and extension. The child was able to pull up to a standing position, but relied totally on his left lower extremity for support. His heel cord contracture was treated with a Strayer gastrocnemius recession and cast application, followed by resumption of AFO bracing.

At 3 years of age, the child exhibited normal upper extremity strength and function. He continues to demonstrate diminished bilateral lower extremity neurological function with more neural deficit on the right than the left and uses bilateral knee-ankle-foot orthoses for short-distance ambulation and a wheelchair for longer distance mobility.

DISCUSSION

Fetal neurologic injury after a gunshot wound has been reported in two patients.[3,7] Weissman et al. reported a full gestational age fetus who sustained a penetrating gunshot wound to the left parietal region of the head. A porencephalic cyst developed, in which the projectile was freely mobile. Six weeks after injury, the projectile was removed, and when follow-up was stopped at 1 year of age, the child had only mild hypotonicity of the right side, but effective use of the extremities.[7] Edner et al.[3] reported a gunshot wound to a 32-week fetus in which the bullet lodged in the base of the skull at the anterior portion of the right parietal region close to the coronal suture. A subependymal bleed was noted at 2 weeks follow up, and at 9 months the patient had the bullet removed, at which time at head CT showed moderate brain atrophy close to the bullet. No permanent neurologic sequelae could be shown at 18 months of age. In these two reports of in utero gunshot wounds with a neurologic insult, the fetus survived and recovered from the deficit. Our case was unique in that the fetus survived the in utero gunshot wound, but was left with a permanent neurologic deficit as a result of a spinal cord injury. No other case reports were found involving injury to the spinal cord with survival of the infant.

This case highlights the need for a multidisciplinary approach to in utero penetrating trauma and the need for a thorough neurological examination to avoid missing a spinal cord injury. Early recognition of a spinal cord injury is critical in determining prognostic value. Close follow-up is required because the neurological status can continue to evolve over time.

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Scapular Notching in Revision Reverse Total Shoulder Arthroplasty

ABSTRACT

Purpose: Scapular notching has been well studied in primary reverse total shoulder arthroplasty (RTSA), but the rate and severity of notching in revision RTSA are unknown. The primary goals of this study were to compare notching in revision and primary RTSA and to evaluate the effect of glenosphere offset in revision RTSA.

Methods: Sixty-two primary and 21 revision RTSAs performed by a single surgeon with a minimum of 1-year radiographic follow-up were evaluated. Revision was defined as a shoulder with previous extensive open surgery, including fracture fixation and arthroplasty. Radiographs were evaluated with the Nerot-Sirveaux grading system for notching severity, and the position of glenosphere offset was noted as inferior, standard, or superior.

Results: Notching occurred in 11 (18%) primary RTSAs and 9 (43%) revisions (p=.03). Inferior glenosphere position was associated with notching in 5 of 41 (12%) primary procedures and 5 of 11 (45%) revision procedures (p=.006). Of the 20 shoulders with radiographic notching, 16 were grade 1, 2 were grade 2, and 2 were grade 3 (both in revisions).

Conclusions: Scapular notching is significantly more common in revision than primary RTSA. The more complex pathoanatomy, including soft-tissue scarring and glenoid bone loss, that can constrict options for glenosphere placement may contribute to the higher rate of notching in revisions. An inferiorly offset glenosphere reduced the rate of scapular notching in primary RTSA but was not protective in revisions. Most notching was mild in both primary and revision groups, and more severe notching occurred only in revisions.

Level of Evidence: Level III, retrospective cohort study

Keywords: reverse total shoulder arthroplasty; revision; complications; scapular notching; functional outcomes

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The Effect of Mood Disorders on the Outcomes of Reverse Total Shoulder Arthroplasty

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Background: Mood disorders such as depression and anxiety are highly prevalent psychiatric disorders in the general population. The effect of mood disorders on outcomes of knee and hip arthroplasty procedures has been extensively studied in recent years; however, there is a lack of data on its effect on outcomes of shoulder arthroplasty. We examined the impact of mood disorders on 90-day outcomes of reverse total shoulder arthroplasty (RTSA) in terms of postoperative visual analog score (VAS), postoperative narcotic usage, and complication rates.

Materials and Methods: This was a retrospective case-control study of 180 patients (190 shoulders) undergoing RTSA. Patients were classified as having a mood disorder by documentation of taking a prescription mood-stabilizing drug on their health history intake forms. Outcome measures were completed preoperatively and up to 90 days postoperatively. VAS scores, postoperative narcotic usage measured by daily oral morphine equivalents (MME), and complication rates in those who had a mood disorder and those who did not were compared. Statistical analyses included Fisher's exact test for dichotomous variables and Student's t-test for continuous variables.

Results: Sixty-two (32%) patients were classified as having a mood disorder. The mood disorder cohort was at an increased risk for higher VAS scores at 12 weeks (p 0.04, CI 0.32-1.79) ; however, the mood disorder cohort was not at an increased risk for higher VAS scores at 2 and 6 weeks or for an increased complication rate or increased postoperative narcotic use.

Demographics (190 shoulders, 180 patients)	
Age	70.0 years
Sex	63 M/ 117 F
BMI	30.5
Side	104 R/86 L
Mood Disorder	62

Results	
Narcotic use (MME/day)	7.2mg
VAS at 2 weeks	2.7
VAS at 6 weeks	2.3
VAS at 12 weeks	2.2
Complications	7

Conclusion: Not only is there a high prevalence of mood disorders in the general population, but having a mood disorder may result in increased patient-perceived pain scores up to 3 months postoperatively. Even though 3-month pain scores may be worse for patients with psychopathology, these patients were not at an increased risk for complications or increased postoperative narcotic usage.

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Outpatient Shoulder Arthroplasty Patients Express High Levels of Satisfaction

Background: Outpatient shoulder arthroplasty has recently been shown to be a safe alternative to hospital admission in appropriately selected patients. However, little is known regarding patient perceptions of the procedure in this setting. We proposed to evaluate patient reported satisfaction with outpatient shoulder arthroplasty performed in a free-standing ambulatory surgery center (ASC).

Methods: Following Institutional Review Board approval, patients undergoing primary outpatient shoulder arthroplasty were mailed a custom survey. The questions addressed patient satisfaction regarding the surgery and location utilizing a 5 point Likert scale. Satisfaction with the ASC environment versus a hospital was assessed with a nominal scale. Patients were also asked whether they would have the surgery again utilizing a nominal scale. All patients were more than 90 days removed from their procedures at the time of survey. Patients who did not respond by mail were subsequently contacted by telephone to provide complete data.

Results: Twenty patients completed the survey; there were 17 anatomic total shoulder arthroplasties (TSA) and 3 reverse total shoulder arthroplasties (RTSA). Of the 20 respondents, 19 (95%) were "extremely" or "very" satisfied with their experience at the ASC and all twenty patients would consider having surgery at the same center again. Additionally, 19 patients (95%) were happy the procedure was done at an ASC rather than at a hospital. Seventeen of 20 (85%) were "extremely" or "very" satisfied with their surgery overall and one patient (5%) would not have the surgery again.

Conclusion: Patients undergoing outpatient shoulder arthroplasty expressed high levels of satisfaction with the operation in the ASC environment. Further, patients were happy to avoid hospital admission following the procedure. And most patients would repeat the experience if given the opportunity. These data suggest that patients perceive outpatient shoulder arthroplasty to be a preferable alternative to the traditional inpatient setting.

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Cervical Spine Stabilization in Patients Actively Receiving Perioperative Heparin Anticoagulation Treatment

Background: In trauma patients with a cervical spine injury, associated cerebrovascular injuries may lead to the initiation of anticoagulation treatment before necessary surgical stabilization of the spine. Literature regarding the safety and efficacy of these procedures while a patient is on active anticoagulation therapy is limited. To determine the safety of cervical spinal surgery in patients actively undergoing heparin anticoagulation at a level 1 trauma center, we compared outcomes in patients with and without heparin use.

Methods: Between May, 2013, and November, 2015, 14 patients with cervical spine trauma who had spinal stabilization while on heparin anticoagulation treatment were identified. Eleven patients had anterior cervical procedures and 3 had posterior fixation. A control group of 49 patients who had cervical stabilization but required no anticoagulation perioperatively were used for comparison (33 with anterior procedures, 16 with posterior fusions). Chart review of outcomes and associated complications was completed for both cohorts and the two groups were compared.

Results: Of the 14 patients who received perioperative anticoagulation treatment, 11 had successful operations that healed without incident. Two postoperative complications (one fixation failure requiring reoperation and a case of pneumonia) and one incidence of elevated PTT were reported; however, there were no anticoagulation-related complications. These complications were comparable to the five postoperative complications that occurred in the control cohort (one fixation failure requiring reoperation, three cases of pneumonia, and one patient who developed acute respiratory failure). Furthermore, ASIA neurologic examination grades demonstrated no neurologic decline postoperatively.

Conclusions: While it is preferable to avoid undertaking spinal procedures in patients actively receiving anticoagulation treatment, this retrospective review revealed that, when necessary, patients on heparin can successfully undergo spinal stabilization procedures, although close monitoring is required.

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Can Glenoid Rim Fracture After Primary Arthroscopic Bankart Repair Be Predicted?

ABSTRACT

Background: Shoulder instability is highly prevalent among the active population. Management of recurrent shoulder instability resulting from glenoid bone loss has been a topic of much debate in the recent literature. The use of bioabsorable anchors for stabilization of the capsulolabral complex has made glenoid rim fractures a rare complication, but it remains a difficult one to treat. Because of the paucity of literature on risk factors for glenoid fractures after arthroscopic stabilization of Bankart injuries, we studied the incidence and risk factors associated with glenoid rim fractures in a cohort of patients who had glenoid fractures after primary arthroscopic Bankart repairs.

Methods: After IRB approval, a database search was conducted to identify patients with primary arthroscopic Bankart repairs at our institution. Patients were divided into two cohorts: those who had a documented postoperative instability episode with a glenoid rim fracture and those who had an instability episode but no fracture. Anchor implant characteristics, presence and number of osteolytic lesions, as well as need for revision surgery, were evaluated and compared between the patients with a glenoid fracture and those without a fracture. Statistical analyses were performed using Fisher's exact test for dichotomous variables and Student's t-test for continuous variables. Differences with $p<0.05$ were considered statistically significant.

Results: Fifteen patients were included in the study, 7 with postoperative glenoid fractures and 8 without fractures. There were no statistically significant differences between the two groups in regard to patient demographics (age, gender, BMI, dominant arm, recurrent dislocator) or in regard to the number and position of anchors used to stabilize the capsulolabral complex, anchor size, or anchor material ($p = 0.36$, $p = 0.84$, $p = 0.51$, $p = 0.57$, respectively). Also, the presence of osteolysis and the number of osteolytic lesions were not significant between the two cohorts ($p = 0.99$, $p = 0.91$, respectively)

Patients who sustained a glenoid rim fracture after a postoperative instability event were significantly more likely to require a secondary procedure to ensure glenohumeral stability ($p = 0.007$) than patients with an instability episode but no fracture. The most commonly used secondary procedure was the Latarjet procedure to treat glenoid bone loss.

Conclusions: Management of shoulder instability is not without complications that can become difficult to treat. Some studies have identified as risk factors age <20 years, male sex, joint laxity, collision sports, multiple preoperative dislocations, and the use of fewer than 3 or 4 suture anchors. One suggested cause of glenoid rim fracture after arthroscopic Bankart repair is osteolysis caused by insertion of metal or PLDDA suture anchors. Patients in our study who sustained glenoid rim fractures after primary arthroscopic Bankart repair did not have significant differences in regard to implanted anchor characteristics and osteolysis when compared to patients without a postoperative fracture. Patients with a postoperative glenoid rim fracture were more likely to undergo a secondary procedure using the Latajet technique to ensure glenohumeral stability in the presence of glenoid bone loss. Our results and those in the literature suggest that, while specific risk factors for glenoid rim fractures might not be identifiable in all patients, young patients participating in collision sports should be counseled about the risk of fracture and the necessity of a second operation.

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High-energy Intertrochanteric Femoral Fractures in Young Patients are Associated With a High Complication Rate

ABSTRACT

Intertrochanteric (IT) femoral fractures in elderly patients are common injuries that have been studied extensively; however, little has been written about IT fractures in young patients with high-energy mechanisms of injury (MOI), and the ideal treatment remains unknown. We sought to better define the injury characteristics and outcomes of high-energy IT fractures in young patients treated with either a sliding hip screw (SHS) or a cephalomedullary nail (CMN).

Thirty-seven patients younger than 65 years of age (mean 45 years) with high-energy IT fractures were identified, 21 treated with a SHS and 16 with a CMN. To compare only fractures suitable for fixation with either device, only OTA-AO types 31A1 and 31A2 were included. We compared injury characteristics, measures of surgical quality, treatment outcomes, and complications.

Despite high-energy MOIs, 84% of patients had type 31A1 fractures; 60% presented with an Injury Severity Score of 17 or more, and 78% sustained other injuries. Comparing fractures treated with an SHS or CMN, there were no significant differences in tip-apex distance (TAD), reduction quality, blood loss, or surgical time ($p>0.05$). The overall rate of major complications requiring revision surgery was 13.5%, with no significant difference between implants ($p=0.36$). Young patients with IT fractures often have multi-system trauma. These fractures are difficult to reduce by closed means and are more prone to complications than their geriatric counterparts. In particular, varus collapse occurred at a high rate in fractures treated with SHS, despite relatively simple fracture patterns, satisfactory TAD, and satisfactory reduction quality.

Anteroposterior radiograph of a 31A1 intertrochanteric fracture after fixation with a sliding hip screw.

Anteroposterior radiograph at the second follow-up visit shows varus collapse and failure of the construct at the side-plate.

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Morbid Obesity Increases the Risk of Systemic Complications in Patients with Femoral Shaft Fractures

ABSTRACT

Objectives: To determine if morbidity and mortality were increased in morbidly obese patients who had reamed intramedullary nailing of closed femoral shaft fractures compared to similar patients of normal weight.

Design: Retrospective case-control study.

Setting: Level I trauma center.

Patients/Participants: All patients with closed femoral shaft fractures treated with reamed intramedullary nailing over a 5-year period were identified. Normal weight patients (BMI < 25) were compared to morbidly obese patients (BMI ≥ 40).

Intervention: Reamed intramedullary nailing.

Main Outcome Measurements: Occurrence of postoperative complications.

Results: Of 507 patients with 526 femoral shaft fractures (AO/OTA 32), 184 (36%) were of normal weight (BMI < 25) and 39 (8%) were morbidly obese (BMI ≥ 40). Systemic complications occurred in 23% of morbidly obese and 9% of normal weight patients (OR 3.15, P=0.013). Morbid obesity increased odds of ARDS (OR 35.38, P=0.019) and sepsis (OR 6.49, P=0.0015). Overall, morbidly obese patients with a femoral fracture had a mortality rate of 10%, but a subset of polytraumatized patients (ISS>17) had a mortality rate of 20%. Morbid obesity significantly increased the odds of mortality (OR 46.77, P=0.01). BMI was found to be an independent predictor of ARDS, sepsis, and death.

	BMI <25	BMI >40	Odds Ratio	95% CI	p value
Any complication	8.7	23.1	3.15	1.28 – 7.78	0.013*
ARDS (%)	0	7.7	35.38	1.79 - 699.7	0.019*
Sepsis (%)	3.3	18.0	6.49	2.05 – 20.6	0.002*
Pneumonia (%)	4.3	5.1	1.19	0.24 – 5.83	0.83
PE (%)	1.6	7.7	5.028	0.97 – 25.9	0.054
Death (%)	0	10.2	46.77	2.46 – 888.21	0.01*

** Statistically significant. BMI, body mass index; CI, confidence interval; ARD, adult respiratory distress syndrome; PE, pulmonary embolism*

Conclusions: Morbid obesity is a significant risk factor for systemic complications in patients with closed femoral shaft fractures, especially in polytraumatized patients. Patients and their families need to be counseled regarding the high risk of morbidity and mortality.

Level of Evidence: Level II, prognostic study.

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Distal Femoral Replacement for Acute Distal Femoral Fractures in Elderly Patients*

ABSTRACT

Objectives: To evaluate outcomes and complications of cemented modular distal femoral replacement in elderly patients with distal femoral fractures.

Patients/Participants: Eighteen patients over 60 years of age (average age 77 years) who had cemented distal femoral replacement for distal femoral fractures (comminuted, intraarticular, osteoporotic, arthritic) between 2005 and 2013. Patients with prior knee surgery were excluded.

Intervention: Cemented modular distal femoral replacement.

Main Outcome Measures: Implant status, complications, Knee Society Score, Musculoskeletal Tumor Society (MSTS) score, and Western Ontario and McMaster Osteoarthritis Index (WOMAC).

Results: All patients were extremely or very satisfied with their outcomes. For patients with complete functional data, knee score averaged 85.7 with a functional score of 35, MSTS score averaged 19.2, and WOMAC score averaged 23.1 at an average follow-up of 2.3 years. Range of motion was 1 to 99 degrees. Implant-related complications occurred in two patients (11%); one required revision to total femoral replacement because of a periprosthetic fracture, and one had a deep infection that required exchange of the components. No patient had aseptic loosening or patellar maltracking. There were no perioperative deaths or late amputations.

Conclusions: Cemented modular distal femoral replacement is a viable treatment option in elderly patients that enables immediate full weight-bearing, with most patients returning to preoperative functional status.

Key Words: distal femoral fracture, elderly patients, cemented mod-ular replacement, outcomes, complications

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

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INTRODUCTION

Distal femoral fractures occur in a bimodal distribution, with low-energy trauma in elderly patients and high-energy injuries in young adults. The annual incidence of distal femoral fractures is 4.5 per 100,000 adults, with a male-to-female ratio of 33:67,[1] and 50% of these fractures occur in patients older than 70 years.[2] Given the rapid expansion of this patient population, the number of distal femoral fractures in elderly patients will continue to increase.

Restoration of or improvement upon pre-injury levels of function presents multiple difficulties in the treatment of distal femoral fractures in elderly patients. Lower pre-injury activity levels and bone quality combined with more medical comorbidities lead to worse outcomes after fixation than in a younger patient population[3–5]: the 1-year mortality rate after this injury is 22%, with a 9% late above-knee amputation rate in elderly patients.[3]

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Nonoperative treatment with immobilization and pro-tected weight-bearing is poorly tolerated because of the associated morbidity of prolonged recumbency, including pneumonia, skin breakdown, and thrombo-embolic disease.[5] Open reduction and internal fixation (ORIF) with locking plates is less successful in elderly patients because of osteo-porosis and degenerative joint disease. Osteoporotic bone is less able to support internal fixation to resist axial and tor-sional loading or to buttress impacted articular segments.[6] Restoring anatomic alignment in a knee with degenerated anatomy is difficult, and many patients initially treated with ORIF require delayed knee arthroplasty.[7] Elderly patients also may be unable to adhere to protected weight-bearing regi-mens because of baseline weakness and decreased cognitive status leading to failure of fixation.

Arthroplasty is an accepted initial treatment for comminuted fractures of the proximal and distal humerus, as well as the femoral neck and acetabulum, in elderly patients.[8] Primary prosthetic replacement avoids the early and late issues associated with internal fixation, such as mal-union, nonunion, osteonecrosis, and need for delayed arthro-plasty. Use of a tumor endoprosthesis for acute distal femoral fractures has been described.[9–11] Cemented modular distal femoral replacement enables immediate full weight-bearing, which facilitates mobilization and avoids the com-plications of prolonged recumbency. The purpose of this study was to evaluate outcomes of a cemented modular rotating-hinge distal femoral endoprosthesis as a treatment option for elderly patients with distal femoral fractures.

PATIENTS AND METHODS

Approval was obtained by the University of Tennessee Institutional Review Board before retrospective data collec-tion. Included were patients older than 60 years with acute traumatic distal femoral fractures treated with cemented distal femoral replacement. Patients who had previous surgery for knee injuries were excluded. Relative indications for the distal femoral replacement were comminuted fractures, intra-articular fractures, osteoporotic bone, and preexisting degen-erative joint disease **(Fig. 1)**. The assessment of presence of significant osteoporosis was made by the treating surgeon using standard radiographs; no DEXA scans were used. Because weight-bearing films to assess joint space narrowing were not possible, the severity of degenerative joint disease was determined by the presence of subchondral sclerosis, subchondral cyst formation, and periarticular osteophyte for-mation. These patients were deemed likely to incur higher failure rates with traditional ORIF or to require arthroplasty after ORIF.

Medical records were reviewed to determine mecha-nism of injury, medical comorbidities, length of hospital stay, disposition after discharge, and outcome measures, including range of motion, stability, and postoperative complications. The objective data reported by the physician at the most recent office visit were recorded. Patients were asked to complete several questionnaires at follow-up appointments: Knee Society Score, Musculoskeletal Tumor Society (MSTS) score, and Western Ontario and McMaster Osteoarthritis Index (WOMAC) score. The Knee Society Score is a functional scoring system with 100 points scored on the basis of pain, range of motion, alignment, stability, and function. The WOMAC score has a maximum of 96 points and is based on patient symptoms, stiffness, pain, and function with activities of daily living. The MSTS score is based on 6 categories (pain, function, emotional acceptance, support, walking ability, and gait) scored from 0 to 5 for a maximal score of 30. Some patients declined to complete these questionnaires. The information from these question-naires, if available, from the most recent office visit was used for evaluating outcome. Radiographs were routinely obtained at each follow-up visit.

All patients signed informed consent after verbalizing understanding the risks, benefits, and alternatives to the proposed surgical procedure. Patients with open frac-

Figure 1: Anteroposterior (A) and lateral (B) radiographs of comminuted, intraarticular distal femoral fracture with degenerative joint disease.

tures had initial debridement and irrigation, followed by resection and placement of an antibiotic spacer before distal femoral replace-ment. The implant system used was the LPS Limb Preservation System (DePuy Synthes, Warsaw, IN). This is a tumor prosthesis with modular distal femoral components, a cemented femoral stem, modular tibial components, and a rotating hinge articulation.

The procedure was primarily performed through an anterior midline incision. A direct lateral approach was used for open fractures where the traumatic arthrotomy made this approach more appropriate and for fractures that extended to the mid-diaphysis of the femur because of the extensibility of this approach. The distal femoral fracture fragments were resected by subperiosteal dissection and retained on the operating room back table to allow for approximate sizing of components to aid in joint line restoration. After a 1-cm proximal tibial cut, the tibial canal was sequentially reamed and broached to the appropriate size, followed by assembling of the final components. The tibial components were placed in a press-fit fashion with a small amount of cement beneath the tibial tray. The femoral canal was reamed sequentially, and trial components were assembled in the femur. Trialing was performed to assess rotation and patellar tracking. A canal plug was placed, and the femoral canal was cleaned with a bottle brush and then pulsed lavage and dried. The canal was filled retrograde with pressurized gentamicin bone cement, and final components were cemented into place **(Figs. 2, 3)**. The wound was closed in layers with absorbable sutures.

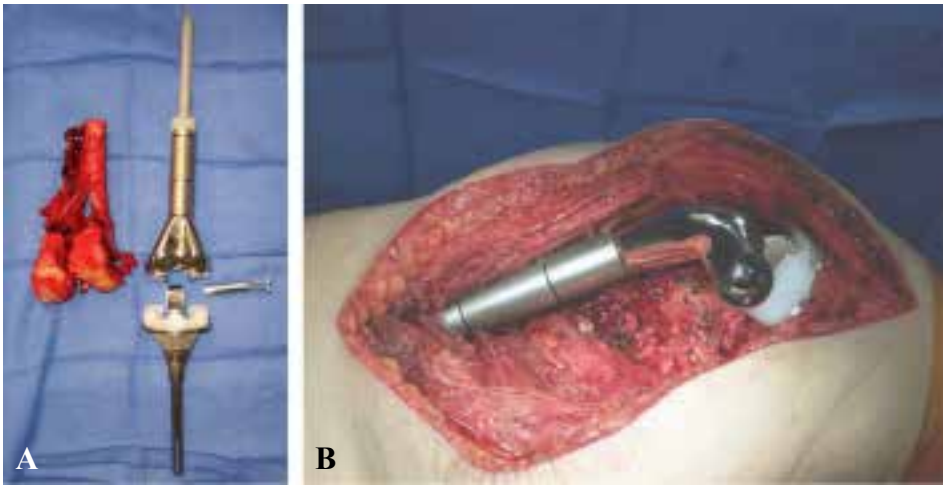

Figure 2: Clinical photos of distal femoral resection adjacent to prosthesis (A) and prosthesis after implantation (B). Editor's Note: A color image accompanies the online version of this article.

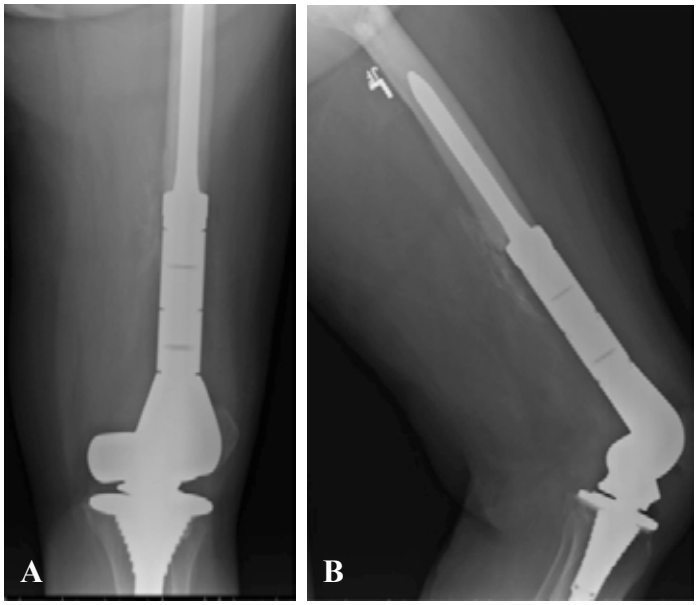

Figure 3: Anteroposterior (A) and lateral (B) radiographs after distal femoral resection and implantation of prosthesis.

Postoperatively, all patients were allowed immediate full weight-bearing. Physical therapists worked with patients twice daily while in the hospital, with immediate range of motion and strengthening as tolerated. Disposition location was determined in conjunction with the physicians, physical therapists, and case managers, and decisions were based on the patient's assistance requirements, progress in physical therapy, and family support available.

RESULTS

Eighteen patients with an average age of 77.1 years (range, 62–94 years) met inclusion criteria for the study. Dur-ing this same period, 125 patients were treated with ORIF for an intraarticular distal femur fracture (CPT Code 27513). Med-ical comorbidities in the group included heart disease (50%), diabetes (33%), hypertension (83%), and liver disease (6%). Mechanism of injury was a same-level fall in 14 patients and a motor vehicle accident in 4 patients. Four patients had open fractures, all Gustilo type II. Average time to definitive surgery for closed fractures was 7 days and for open fractures was 11 days. The average intraoperative blood loss was 344 mL, with a tourniquet time of 100 minutes. The average American So-

ci-ety of Anesthesiologists class was 3 (severe systemic disease). The average length of hospital stay was 11 days (range, 5–43 days); 12 patients were discharged to inpatient rehabilitation facilities, 5 to skilled nursing facilities, and 1 to home. All patients were permitted to bear full weight postoperatively. At average follow-up of 2.2 years (range, 0.3–5.9 years), the average range of motion was 1–99 degrees. Eight patients died an average of 4.7 years after surgery of causes unrelated to their fracture. All prostheses in the remaining 10 patients currently are well-functioning.

Complications

Overall, complications occurred in 7 (39%) patients; however, implant-related complications occurred in only 2 (11%). One patient had a periprosthetic fracture that required revision to a total femoral prosthesis, and 1 patient had a deep infection that required debridement and irrigation and exchange of the modular components (well-fixed stems were retained). No patients had aseptic loosening, patellar maltrack-ing, or loosening of components. Complications are listed in **Table 1**.

Patient A became hypotensive on the evening of surgery and was transferred to the intensive care unit for observation. The hypotension responded to volume replace-ment, and the patient returned to the floor 2 days later and had no further complications.

A 2-cm stage 2 gluteal decubitus ulcer developed postoperatively in patient B while an inpatient; it healed with superficial wound care and prophylactic cephalexin.

During preoperative evaluation, patient D was found to have severe 3-vessel disease and underwent coronary artery bypass grafting before treatment of the femoral fracture 7 days later. This patient developed a nonocclusive thrombus of the deep femoral vein after coronary artery bypass grafting and before distal femoral replacement, which was treated with an inferior vena cava filter. This patient also developed thrombosis-associated heparin-induced thrombocytopenia that was treated with

Patient	Age, y	Mechanism	AO Class	Open (O)/ Closed (C)	Time to OR, d	Time to Death, mo	Followup, mo	Pre-Injury Assistive Device	Postinjury Assistive Device	Complications
A	82	SLF	C	C	2	49.5	7.5	NA	NA	Hypotension
B	77	SLF	C	O	2	13.3	12.1	Walker	Cane	Stage 2 gluteal decubitus ulcer
C	77	SLF	C	C	8	50.2	4.1	Cane	NA	-
D	94	SLF	B	C	9	N/A	32.3	Walker	NA	DVT
E	81	SLF	B	C	2	N/A	70.8	Cane	NA	Superficial suture abscess
F	71	SLF	C	O	3	N/A	14.0	NA	None	-
G	62	MVA	C	C	1	N/A	12.2	NA	None	-
H	65	MVA	C	C	17	N/A	10.0	NA	None	-
I	84	SLF	C	O	5	64.6	13.0	NA	None	-
J	75	SLF	C	C	2	N/A	28.0	None	Cane	-
K	87	SLF	C	C	7	114.8	62.9	Walker	Walker	-
L	78	SLF	C	C	4	76.6	49.6	Walker	Walker	Deep infection
M	76	SLF	B	C	4	N/A	3.8	Walker	Walker	-
N	73	MVA	C	O	35	N/A	60.7	None	None	-
O	76	MVA	C	C	3	82.2	28.9	NA	None	Respiratory insufficiency
P	63	SLF	C	C	27	3.2	2.8	None	Cane	-
Q	81	SLF	B	C	2	N/A	35.7	None	None	-
R	85	SLF	C	C	7	N/A	27.6	None	NA	Interprosthetic fracture

MVA, motor vehicle accident; SLF, same level fall; NA, unknown.

Table 1: Patient Complications With Ambulatory Status Before and After Injury, as Documented in the Medical Record

6 months of anticoagulation. At 3-year follow-up, the patient was doing well.

Patient E presented 1 year after surgery with a stitch abscess on the anterior aspect of the knee. This was opened and cultures grew gram-positive cocci. An aspiration of the knee showed no growth. Despite treatment with oral anti-biotics, drainage from the anterior aspect of the knee continued, and formal debridement and irrigation of the superficial tissues and closure were done. No arthrotomy was performed. This incision healed, and the patient was doing well at the most recent follow-up 5.8 years after the initial procedure.

Patient L presented 4 weeks after surgery with wors-ening knee pain and redness. The knee was aspirated and showed gram-positive cocci on Gram stain. Debridement and irrigation of the knee were done, with placement of antibiotic beads and retention of the components. The cultures from this procedure eventually grew methicillin-resistant Staphylococcus aureus. Six days after the initial debridement and irrigation, repeat debridement was done, with exchange of the modular components and placement of new antibiotic-impregnated cal-cium sulfate beads. The femoral body and the rotating hinge polyethylene components were exchanged while retaining the well-fixed femoral stem and tibial components. The decision was made to continue suppressive minocycline indefinitely. Two years later, however, the patient returned to clinic com-plaining of increasing knee pain after admitting that she had stopped taking her antibiotics. A repeat aspiration grew Serra-tia marcescens. Debridement and irrigation were done, with polyethylene exchange and replacement of antibiotic-impregnanted calcium sulfate beads. The patient was success-fully treated with oral suppressive antibiotics until her death 6.3 years after distal femoral replacement.

Patient O had a history of chronic obstructive pulmo-nary disease and sustained a distal femoral fracture along with bilateral rib fractures in a motor vehicle accident and remained intubated in the intensive care unit for 2 days after surgery because of respiratory failure. This patient was transferred to the floor on the third postoperative day and had an unremarkable further hospital course.

Patient R sustained a distal femoral fracture ipsilateral to a primary total hip replacement done 6 years earlier. She had distal femoral replacement without complication and was well until 2 years later when she fell and sustained an interprosthetic fracture between the hip and distal femoral implants. She had revision to a total femoral prosthesis and was well at latest follow-up 3 years after surgery, with a Knee Society Score of 90.

Functional Outcomes

Of the 18 patients, complete follow-up data consisting of MSTS, Knee Society, and WOMAC scores were available for 12 patients at an average of 1.7 (0.6–5.2) years after surgery. Knee Society Score averaged 85.7, with a functional score of 35, the MSTS score averaged 19.2, and the WOMAC score averaged 23.1. All 12 patients reported being extremely or very satisfied with their outcome at latest follow-up. Of the 13 patients for whom documentation was available, 12 re-turned to their baseline functional status and 1 patient who was previously ambulated without any assistive device required a cane. Eight of the 18 patients were followed until they died an average of 4.7 years after surgery. For the sur-viving 10 patients, follow-up averaged 2.5 years and all cur-rently have well-functioning prostheses.

DISCUSSION

To our knowledge, this is the largest study of acute modular endoprosthetic reconstruction of distal femoral fractures in a native knee. All patients were allowed to ambulate full weight-bearing immediately after surgery, and there have been no mechanical complications to date. One patient required revision to a total femoral replacement because of an interprosthetic fracture. Twelve of 13 patients returned to their preoperative functional levels, with 1 patient who previously did not use any assistive device requiring a cane. All patients reported being extremely or very satisfied with their outcomes at latest follow-up. This is the first study to report functional scoring outcomes for this treatment method for acute distal femoral fractures in elderly patients. At time of this report, all surviving patients have well-functioning prostheses; 8 of the 18 patients were deceased at an average of 4.6 years after surgery.

Although ORIF with locked plating is the most common treatment method for distal femoral fractures, unique patient factors in the elderly population make this a more challenging treatment option than in younger patients.[8,12–14] ORIF generally requires restricted weight-bearing for 6 weeks to 3 months,[15] with which many elderly patients may be unable to comply.[16] Because of poor fixation in osteoporotic bone, loss of reduction

may occur with late sequelae of posttraumatic arthritis, mal-union, nonunion, and stiffness. Some authors have recommen-ded supplementing internal fixation with spanning external fixators to overcome insufficient fixation in osteoporotic bone.[17] A retrospective study of 70 distal femoral fractures in patients with an average age of 60 years showed a nonunion rate of 20%, complication rate of 40%, and reoperation rate of 27%.[18] Because restricted weight-bearing precautions may result in other medical complications due to prolonged immobility, some have suggested allowing early weight-bearing after ORIF; however, a recent biomechanical study suggests that failure of fixation would be likely even in young patients.[19]

After fracture healing is complete, many patients with ORIF require total knee replacement. Total knee replacement in this setting, even though technically a primary joint replacement, is significantly more difficult because of joint contractures, difficulty with surgical exposure, and use of allograft and revision components.[4] Total knee replacement as a secondary procedure following periarticular fracture has disappointing results when compared with elective primary arthroplasty. Revision rates vary between 8% and 23%, with a complication rates of 24%–48% and "good" outcomes in 60%–70%.[20,21] A study by Papadopoulos et al[7] of 48 total knee arthroplasties in patients with previous distal femoral fractures showed an 8% revision rate, 15% complication rate, and 52% good outcomes.

There have been limited reports of acute arthroplasty using revision knee implants for distal femoral fractures. This was first described in 1982,[22] and the first studies of multiple patients were reported in 1989[23] and 1992.[2] Results of pri-mary arthroplasty for acute distal femoral fractures have shown better outcomes than arthroplasty as a secondary pro-cedure after ORIF of a distal femoral fracture.[2,24–26] Bell et al[2] reported a 15% complication rate and 85% good outcomes in 13 patients; however, follow-up was limited to 6 months. At 3-year follow-up, Malviya et al[24] reported 90% patient satis-faction and 81% return to pre-injury level of function after acute primary total knee arthroplasty for 26 periarticular knee fractures using stemmed cemented components. In this study, although, only 11 were for distal femoral fractures and the manner of data reporting does not permit comparison of out-comes to our study. In a small study comparing 6 elderly patients with no preexisting arthritis treated with a stemmed revision-type implant with 4 patients with internal fixation, the arthroplasty group showed a larger portion returning to independent walking, with quicker rehabilitation and better knee flexion.[25] Appleton et al,[26] however, reported using fixed-hinge, long-stemmed revision implants for acute distal femoral fractures in 54 medically frail patients who did not ambulate outside the home and showed a 41% 1-year mor-tality in this fragile population.

Use of modular tumor prostheses for non-tumor diagnoses including trauma has been reported.[4,9,27,28] In a study from the Mayo Clinic of 26 knees treated with tumor prostheses for nonneoplastic limb salvage, 11 were for non-union of a periprosthetic fracture, 8 for revision arthroplasty with severe bone loss, 4 for nonunion of supracondylar fem-oral fractures, and 1 each for an acute periprosthetic fracture, fracture of a previous hinge implant, and a previous resection arthroplasty. None were used for an acute distal femoral frac-ture in a native knee. All the patients gained significant im-provements in range of motion and functional scores.[27] Freedman et al[9] reported 2 patients with acute distal femoral fractures treated with modular distal femoral replacement and noted immediate pain relief, early weight-bearing, and ability to proceed with aggressive rehabilitation. Berend and Lombar-di[28] described 39 distal femoral replacements for non-tumor cases, including 13 periprosthetic fractures and 1 acute distal femoral fracture, with an 87% implant survivorship rate at 46-month follow-up. In 24 patients with acute distal femoral replacement using a rotating hinge tumor prosthesis for both acute distal femoral fractures or nonunions, Rosen and Strauss4 reported 100% immediate weight-bearing, 8% complications, no revisions, and 71% return to preoperative ambulation levels. This study, however, was limited to short-term follow-up of a mean of 11 months (range, 5–23 months) and no functional scoring of results.

Most intraarticular distal femoral fractures at our institutions are treated with ORIF with locked plating constructs, including those in patients older than 60 years. Endoprosthetic reconstruction is offered only to those patients in whom ORIF is deemed likely to fail or who may require secondary procedures because of poor bone quality or preexisting degenerative joint disease. We have found this specific patient population to be better treated with endopros-thetic reconstruction. The exclusion of patients with previous knee surgery may explain in part the favorable comparison of our results to those for arthroplasty after internal fixation.[7,21,22] Given the lower

activity level in elderly patients, implant survivorship is less of an issue than with younger, more active patients.

Our complication rate and functional results after endoprosthetic reconstruction compare favorably with those after ORIF in the geriatric population.[29–33] Konda et al[30] recently reported 30-day mortality, adverse events, and severe adverse events of 4.51%, 20.05%, and 12.03%, respectively, after ORIF in geriatric patients, and Smith et al[32] found an 18%1-year mortality in patients (mean age of 77 years) with distal femoral fractures, most of which were treated with locked plating. Thomson et al[33] found no difference in the SF-36 physical functioning score between patients with intraarticular distal femoral fractures treated with ORIF and those treated with intramedullary nails; the score was approximately 2 SDs below population norms in both groups. Good or excellent results were obtained in only 45.9% of 111 distal femoral fractures treated with locked plates by Hoffman et al.[29] Shul-man et al[31] reported "relatively good" functional results, based on Short Musculoskeletal Functional Assessment, after ORIF or intramedullary nailing of intraarticular distal femoral frac-tures. Elderly patients did have worse functional outcomes than younger patients in the Short Musculoskeletal Functional Assessment indices of Daily Activity, Functional, and Bother.

This operation can be technically demanding and is likely best suited to surgeons familiar with the procedure and who perform it regularly. The cost of this operation is significant as the components are several times more expensive than a standard distal femoral locking plate, although it may be less expensive overall than a case of a failed ORIF that requires additional hospitalization and revision arthroplasty compo-nents. The average time to definitive surgery for open and closed fractures is relatively high; however, as shown in **Table 1**, there were several outliers that increased the overall average. In addition to waiting for open wounds to stabilize and be without concern for infection, additional factors that increased time to surgery included preoperative medical clearance and coordination of care between hospitals and the orthopaedic trauma and arthroplasty surgeons. Patients with open fractures were not routinely kept on antibiotics while awaiting definitive surgery. Although patients with an antibiotic spacer were touch down weight-bearing on the involved extremity, they still returned to full weight-bearing sooner than the 6-week interval that would be typical had they undergone ORIF.

Weaknesses of this study include those inherent to its retrospective design and relatively short follow-up. Complete functional scoring was not available for 5 of the 18 patients at latest follow-up, and they lacked documentation of their preoperative functional levels, which prevented comparison to their postoperative functional status.

CONCLUSIONS

Intraarticular distal femoral fractures in elderly patients are difficult to treat because of poor bone quality, preexisting joint disease, and multiple co-morbidities. Modular endo-prosthetic distal femoral replacement is an option that allows immediate full weight-bearing and restores most patients to their preoperative functional status.

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Campbell Foundation Achievements

Jack R. Blair

Chairman, Board of Trustees
Campbell Foundation

Throughout my career in orthopaedics, I have seen first-hand the transformative impact of innovation and technology to deliver solutions to challenging clinical solutions. These innovations only occur through the diligent pursuit of research projects - retrospective and prospective - that illuminate trends and opportunities for advancement. I continue to take pride in the research achievements of the orthopaedic surgeons, fellows, residents, and scientists of Campbell Clinic made possible through research support from the Campbell Foundation. This journal includes a sample of the breadth and depth of our clinical research.

During each meeting of the Campbell Foundation Board of Trustees, we review our progress against our strategic goals, which were identified five years ago, and which serve to advance our mission to ***enhance quality of life through the science of orthopaedic medicine***. The trustees help the Campbell Foundation to focus on the impact of the research; the benefits to patients. We strive to encourage the surgeons and researchers to always remember the beneficiaries of our research - to accelerate the discovery of better answers to challenging clinical questions for patients everywhere. Furthermore, we then strive to share our findings with others in our profession so as to broaden the impact beyond our own patient populations.

Despite our breadth of orthopaedic subspecialties, the uniting factor and focus of our research remains the "sweet spot" at the intersection of

- areas of clinical expertise at Campbell Clinic where we could provide unique insights,
- issues of clinical significance in our local area, and the orthopaedic community in general, and
- those areas likely to be supported by grants, donors and others interested in innovation.

In the current healthcare economic climate, discussions of the "value" of orthopaedic interventions are frequent. By examining our outcomes along with our costs, we can determine the value we are adding to the system. Complex orthopaedic surgeries are now being performed in the outpatient setting, and we strive to demonstrate the safety and optimum processes and procedures to ensure that patient results - in terms that matter to them - are of the highest quality. Combined with patient satisfaction measurements, we can deliver genuine solutions to orthopaedic challenges - solutions that allow patients to return to active, productive lives sooner and better.

Ongoing donor support sustains our momentum and can expand our impact. I hope you see the potential of the work in these pages and will join us in our efforts to expand this research. Only through research and innovation will we be able to provide enhanced quality of life for patients everywhere. I invite you to visit the Campbell Foundation website today (campbell-foundation.org), and please give generously to help expand our impact.

Jack R. Blair, Chairman
Campbell Foundation Board of Trustees

Report from Alumni

Greg Behm, M.D.
Campbell Club President

May, 2017

Dear Campbell Alumni,

Thank you for your continued support of the Campbell Foundation and sustaining its mission of resident education, orthopaedic research, and community healthcare outreach. Your gifts are vital and makes the research activity that fills this issue of *Campbell Orthopaedic Journal* a reality.

During the Academy meeting in March, I had a great time reconnecting with fellow alums and had the opportunity to meet some of the current residents and fellows. What an impressive group of young physicians. We can all be proud of them.

As for the class of 2022, the Campbell Clinic has fully matched again this year. I'm excited to learn more about the 8 future WCC residents and see the impact that training at Campbell Clinic will have on the lives of these young physicians and their families.

In the 18 years since my Campbell residency, I've been amazed at the pace of technology and information change. Today's residents need increasing amounts of academic information and access to the very best educational materials and conferences.

As Campbell Alumni, it is our responsibility to sustain the Campbell tradition of excellence in the way we conduct or practices and our lives. In addition, I believe it is important to financially support the efforts of the Campbell Foundation so that the next generation of Orthopedic Surgeons has every opportunity to excel.

Your gifts strengthen the residency program and help provide these young surgeons with the resources and innovative technology that is essential for their orthopaedic training. Thank you for your continued support.

Sincerely,
Greg Behm '99
Campbell Club President

Campbell Club In Memoriam

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2017 Graduating Orthopaedic Residents

ERIC N. BOWMAN, MD

Hometown: Dayton, Ohio

Undergraduate Institution: Miami University, Oxford, Ohio

Medical School: University of Cincinnati, Cincinnati, Ohio

Dr. Bowman is the first in his immediate family to pursue a medical career. He and his wife Crista, a Human Resources Recruiter at St. Jude Children's Research Hospital, have two children. Elliana and Brielle share the birthday of August 3 – Elliana in 2014, and Brielle in 2016.

Dr. Bowman chose to pursue a career in medicine because it allowed him to have the ability to alleviate suffering and promote health through the integration of science and personal relationships.

Dr. Bowman chose to specialize in orthopaedics because it gave him the opportunity to improve the quality of life for individuals over a spectrum of ages and disease processes through operative and non-operative interventions.

Plans After Campbell: Dr. Bowman will complete a Sports Medicine Fellowship at Kerlan-Jobe Orthopaedic Clinic in Los Angeles, California.

Dr. Bowman extends thanks to the Campbell Clinic faculty and to my fellow residents for inspiring me daily to be a better surgeon and person. "*It has been an honor to know you and learn along-side you every day.*"

JOHN J. FELDMAN, MD

Hometown: Annapolis, Maryland

Undergraduate Institution: Denison University in Granville, Ohio

Medical School: West Virginia University School of Medicine Morgantown and Charleston, West Virginia

Dr. Feldman chose to pursue a career in medicine so he could have an impact in the lives of others in a meaningful way on a daily basis.

Dr. Feldman chose to specialize in orthopaedics because it allowed him to accomplish his goal of helping others while combining his interest in surgery and sports.

Plans After Campbell: Dr. Feldman will complete a Sports Medicine Fellowship American Sports Medicine Institute in Birmingham, Alabama.

Dr. Feldman would like to thank the faculty and staff at the Campbell Clinic who have worked hard to help train him and have served as great role models.

2017 Graduating Orthopaedic Residents

CHRISTOPHER M. HOPKINS, MD

Hometown: Austin, TX

Undergraduate Institution: University of Texas at Austin McCombs School of Business

Medical School: The University of Texas Medical Branch at Galveston

With medicine as a career choice for Dr. Hopkins, he follows in his grandfather's footsteps, who also a physician.

Dr. Hopkins was introduced to medicine by his grandfather at a young age. His grandfather's influence, coupled with his love of science and desire to help people, made medicine an easy choice.

Dr. Hopkins chose orthopaedics because it allows physicians to offer a direct and reproducible intervention to potentially improve a patient's quality of life.

Plans After Campbell: Dr. Hopkins will join a private practice near Austin, Texas.

"Thank you to all of the incredible staff and faculty at the Campbell Clinic. I couldn't imagine a better place to train and am grateful for the opportunity to train here."

NICHOLAS B. JEW, MD

Hometown: Jackson, Mississippi

Undergraduate: Institution University of Mississippi, Oxford, Mississippi

Medical School: University of Mississippi School of Medicine, Jackson, Mississippi

With medicine as a career choice for Dr. Jew, he follows in the footsteps of his uncle who is an orthopaedic surgeon. Dr. Jew and his wife Leisal, a nurse, were high school sweethearts and have two daughters – Caldwell, age 2, and Ellis, 7 months.

Dr. Jew chose medicine because he had a great respect for the medical community. He believes that the work that physicians do is important to the individual, as well as, the community and is something that he aspired to be a part of from a young age.

He was drawn to the field of orthopaedics because his first exposure to orthopaedics was in senior high following a sports injury. His interest expanded during medical school and he found it to be the only specialty that truly excited him.

Plans After Campbell: Dr. Jew will complete a Hand Fellowship at Hospital for Special Surgery in New York City, New York.

Dr. Jew would like to extend his thanks to all of Campbell Clinic faculty and staff for helping him achieve his dream of becoming an orthopaedic surgeon.

2017 Graduating Orthopaedic Residents

MEGAN N. MAYER, MD

Hometown: Kansas City, Missouri

Undergraduate: Webster University, St. Louis, MO

Medical School: University of Missouri-Kansas City School of Medicine, Kansas City, MO

With medicine as a career choice for Dr. Mayer, she follows in her footsteps of her aunt, who is an OB/GYN, and her uncle who is a Psychiatrist.

Dr. Mayer chose medicine because she enjoys the opportunity to help people and the possibility of encountering problems that present themselves in different ways.

She was first introduced to the field of orthopaedics through her own experience after she tore her ACL. Dr. Mayer also enjoys working with her hands and tool, and likes the opportunity orthopaedics presents to instantly improve and impact the lives of patients.

Plans After Campbell: Dr. Mayer will complete a Sports Medicine Fellowship at Methodist Sports Medicine in Indianapolis, Indiana before joining a practice in the Kansas City, Missouri area.

"I thank all faculty and staff for their guidance and embracing me upon entering the program. I am grateful to everyone who took an interest in me and mentored me through residency. I appreciate my fellow residents for their friendship and support as we made our way through the hard and fun times in residency."

ARTURO D. VILLARREAL, MD

Hometown: Bridgeport, CT

Undergraduate: Texas State University-San Marcos, San Marcos, Texas

Medical School: University of Texas Medical Branch, Galveston, Texas

While Dr. Villarreal is the first in his immediate family to pursue a career as a physician, his wife Cynthia is a pediatrician. They have one son, Arturo Benjamin, who is six months old.

Dr. Villarreal chose the medical profession because he enjoyed surgery.

The field of orthopaedics emerged as Dr. Villarreal worked with other orthopaedic surgeons and found the work fulfilling and enjoyable.

Plans After Campbell: Dr. Villarreal will complete a Sports Fellowship program.

Dr. Villarreal expressed thanks to the Campbell Clinic Staff for their time and knowledge – *"top notch training"* – providing him the foundation to launch a successful career.

2017 Graduating Orthopaedic Residents

WILLIAM J. 'JAKE' WELLER, MD
Hometown: Jacksonville, Illinois

Undergraduate: Illinois College, Jacksonville, Illinois

Medical School: Rush University Medical College, Chicago, Illinois

With medicine as a career choice for Dr. Weller, he will join his sister and brother-in-law who are both physicians. Dr. Weller is engaged to be married in June, 2017, to Emily Griesbeck, a pediatric ICU nurse at Le Bonheur Children's Hospital.

Dr. Weller chose the medical field because he was drawn to learning human pathophysiology and applying it to clinical practice.

Dr. Weller chose orthopaedics because he likes the concrete nature of the field and improving the function of patients with musculoskeletal injuries.

Plans After Campbell: Dr. Weller will complete a Hand and Upper Extremity Fellowship at the Indiana Hand and Shoulder Center in Indianapolis, Indiana.

"I would like to say thank you for the patience and helpfulness of all Attendings that I have had the privilege of working under during my time at Campbell Clinic. Your willingness to take time out of your private practice of orthopaedics to teach us residents is greatly appreciated. I would also like to say thank you to the countless number of doctor's assistants, nurses, ancillary staff, and the Campbell Foundation administrators that have been so kind, helpful, and passionate about the mission of the clinic. I am proud to have become part of the Campbell Clinic family and I will always look fondly upon my years here in Memphis."

ANDREW 'DREW' J. WODOWSKI, MD
Hometown: Buffalo, New York

Undergraduate: University of Tennessee, Knoxville, Tennessee

Medical School: University of Tennessee Health Science Center College of Medicine, Memphis, Tennessee

Dr. Wodowski is the first in his immediate family to pursue a career as a physician; however, his wife Brittany is a Pharmacist. They met in college and have twin 19 month old daughters – Evelyn Rose and Emery Jean.

Dr. Wodowski pursued a career in medicine because he always enjoyed studying and learning the sciences but realized that being a research chemist or physicist was not for him. He found interacting with others was natural and enjoyable, so medicine was an easy choice.

Dr. Wodowski chose orthopaedics because he always thought of taking care of orthopaedic patients as a special privilege since a single procedure can relieve pain, restore function, and return someone to mobility. The field allows him to truly change another person's life for the better.

Plans After Campbell: Dr. Wodowski will complete a Fellowship in Adult Reconstruction/Total Joints at the University of Utah.

"I would like to thank the staff and faculty of Campbell Clinic for imparting their knowledge to me. However, you all have taught me so much more than orthopaedics. I learned life lessons, interpersonal skills, and professional practices on a daily basis, and I will look back on this time with pride and gratitude."

2017 Orthopaedic Fellows

ERIC A. BARCAK, DO
Trauma Fellow

Hometown: Houston, Texas

Undergraduate Institution: Baylor University, Waco, Texas

Medical School: University of North Texas Health Science Center, Texas College of Osteopathic Medicine, Ft. Worth, Texas

Orthopaedic Residency: John Peter Smith Hospital, Ft. Worth, Texas

Dr. Barcak is the first in his immediate family to pursue a career in medicine. He and his wife Laurel met on a mission trip to Tanzania, and they have three children – Adleigh, 6 years old, Ayden, 3 years old, and baby #3 due in June.

He chose the specialty of orthopaedic trauma because he doesn't like to win.

Plans After Campbell: Dr. Barcak will return to Fort Worth, Texas, and join the Orthopedic Trauma Staff at John Peter Smith Hospital/Orthopedic Residency Program.

"Thanks to Dr. Perez for his kind greetings every Tuesday morning.

Thanks to Dr. Rudloff for showing me that all fractures can be treated with EVOS and that there is no such thing as comminution.

Thanks to Dr. Weinlein for helping me wrestle through difficult cases.

Thanks to Dr. Beebe for sharing his office and inflatable mattress with me.

Finally, thanks to all the residents for their hard work and support."

BRADLEY P. JAQUITH, MD
Sports Fellow

Hometown: Chattanooga, Tennessee

Undergraduate Institution: University of Tennessee, Knoxville, Tennessee

Medical School: University of Tennessee Health Science Center School of Medicine, Memphis, Tennessee

Orthopaedic Residency: University of Cincinnati, Cincinnati, Ohio

While Dr. Jaquith is the first in his immediately family to pursue a career in medicine, his wife Margaret, whom he met in residency in Cincinnati, is an obstetrician.

Recognizing the opportunity it offered to use his skills in a challenging and rewarding way to help those in need, Dr. Jaquith chose the medical profession. The field of orthopaedics appealed to his appreciation of the technical aspects of surgery and the ability to restore function to patients, allowing them to perform normal activities or get back to the sport they enjoy.

Plans After Campbell: Dr. Jaquith will begin his practice, location to be determined.

"Thank you to Dr. Azar, Dr. Miller, Dr. Throckmorton, and Dr. Mascioli for all your teaching and mentorship. You all set a great example and are true professionals. I appreciate all you have done in preparing me to begin my career."

2017 Orthopaedic Fellows

BENJAMIN W. SHEFFER, MD
Pediatric Fellow

Hometown: Waterloo, Iowa

Undergraduate: Texas A&M University. College Station, Texas

Medical School: Texas Tech University Health Sciences Center, Lubbock, Texas

Orthopaedic Residency: John Peter Smith Hospital, Fort Worth, Texas

Dr. Sheffer is the first in his family to become a physician. He and his wife Amie, who is a high school English teacher, were high school sweethearts and together have two children – Harrison, 3 years old, and Isla, 1 year old.

Dr. Sheffer chose a career in medicine because there are few other fields in which you can genuinely help a person by becoming intimately involved in what ails them. It is a respected profession that allows you to make a real difference in thousands of lives.

Dr. Sheffer chose Orthopaedic Surgery because it affords an opportunity to drastically change someone's life, whether it is relieving insufferable pain, helping the injured to walk and return to their life, or taking care of congenital problems in pediatric patients. Orthopaedic patients love their caregivers and love what they do. Relative to other surgical subspecialties, orthopaedics is a very low risk, high reward field filled with hugs and high fives from patients.

Plans After Campbell: Dr. Sheffer will be joining the staff of Campbell Clinic as a Pediatric Orthopaedic Surgeon Specialist upon completion of his Fellowship.

"The Campbell Clinic opened my eyes to the field of academic medicine that I had not seen in residency, and this drastically changed what I desired for my career in Pediatric Orthopaedics. Dr. Beaty, Dr. Warner, Dr. Sawyer, Dr. Kelly, and Dr. Spence have been instrumental in my development as a surgeon. They have gone out of their way to ensure a good, knowledge filled experience for me, and I am very thankful to have been given the opportunity to train under them."

MURPHY M. STEINER, MD
Hand Fellow

Hometown: Minneapolis, Minnesota

Undergraduate: University of St. Thomas, St. Paul, Minnesota

Medical School: Creighton University School of Medicine, Omaha, Nebraska

Orthopaedic Residency: State University of New York Upstate Medical University, Syracuse, New York

Dr. Steiner joins other healthcare providers in his family including his father, a Physical Medicine and Rehabilitation physician, and his sister who is a Doctor of Pharmacy. Dr. Steiner's wife Erin, whom he met in medical school, is also a physician, an Air Force Pediatrician.

Dr. Steiner chose a career in medicine because he was inspired by his parents, who are both in the medical field. He explained, "They are great role models who encourage me to be successful in all aspects of life."

Dr. Steiner chose the field of orthopaedics because he has a love for the musculoskeletal system and physics – a perfect fit.

Plans After Campbell: Dr. Steiner will be joining Bienville Orthopaedic Specialists on the Mississippi Gulf Coast.

"Thank you to the Campbell Clinic Hand Department staff. It has been a great year, and I consider myself lucky to be here."

2017 Orthopaedic Fellows

BRANDON A. TAYLOR, MD
Foot and Ankle Fellow

Hometown: Bridgeport, CT

Undergraduate: University of South Alabama, Mobile, Alabama

Medical School: University of South Alabama College of Medicine, Mobile, Alabama

Orthopaedic Residency: University of South Alabama Hospital Systems, Mobile, Alabama

Dr. Taylor is the first in his immediate family to become a physician; however, his wife Christin is a family medicine doctor. They met in medical school and have one daughter, Annika Taylor.

Dr. Taylor chose the medical profession after developing an interest in science, engineering, and the human body.

After spending a few days shadowing Dr. Robert McGinley, a Campbell graduate (Class of 1977), Dr. Taylor chose the field of Orthopaedics. "During that time, I saw that orthopaedic surgery dovetailed well with my interests and previous construction job skills. Dr. McGinley also demonstrated how rewarding the job can be as he served others by doing his job well."

Plans After Campbell: Dr. Taylor will be joining a private practice in Palm Harbor, Florida.

"Thanks to all of the faculty, residents, and staff for welcoming us into the Campbell family. We feel truly blessed, and we are really enjoying our time here."

JANE YEOH, BSC, MD FRCSC
Foot and Ankle Fellow

Hometown: Kuala Terengganu, Malaysia

Undergraduate: Simon Fraser University, Vancouver, BC Canada

Medical School: University of British Columbia Medical School, Vancouver, BC Canada

Orthopaedic Residency: University of British Columbia Orthopaedics, Vancouver, BC Canada

Dr. Yeoh is the first in her immediate family to choose a career in medicine. Her husband Denis is a police officer, and they met as paddling teammates and friends.

The desire to positively impact patients' lives, health and well being inspired Dr. Yeoh's pursuit of the medical profession.

Dr. Yeoh chose orthopaedics because she wanted the clinical and surgical skills needed to help improve patients' quality of life. She loves working with orthopaedic teams and enjoys the problem solving aspect of orthopaedics. She chose the foot and ankle specialty because of the variety of orthopaedic solutions and procedures and believes that the field is advancing at an exciting rate.

Plans After Campbell: Dr. Yeoh will complete a Sports and Arthroscopic Reconstruction Fellowship at the University of British Columbia, followed by an orthopaedic practice in Canada.

"Thank you to Dr. Drew Murphy, Dr. Sue Ishikawa, Dr. David Richardson, Dr. Benjamin Grear, Dr. Clayton Bettin, and co-fellow Dr. Brandon Taylor for your friendships and guidance throughout the year."

Current Orthopaedic Residents

INTERNS

J. Stephen Chambers, MD
Undergraduate: Georgia Institute of Technology
Medical School: Mercer University School of Medicine-Savannah

Joseph T. Cline, MD
Undergraduate: Davidson College
Medical School: University of North Carolina at Chapel Hill School of Medicine

Parker P. Duncan, MD
Undergraduate: University of Memphis
Medical School: University of Tennessee Health Science Center College of Medicine

Charles T. Fryberger, III, MD
Undergraduate: Auburn University
Medical School: University of Alabama School of Medicine

Matt 'Jejo' Matthew, MD
Undergraduate: University of Kansas
Medical School: University of Kansas School of Medicine

S. Gray McClatchy, MD
Undergraduate: Mississippi State University
Medical School: University of Arkansas for Medical Sciences College of Medicine

Trenton T. Stevens, MD
Undergraduate: University of North Carolina at Chapel Hill
Medical School: University of Tennessee Health Science Center College of Medicine

Carson D. Strickland, MD
Undergraduate: University of Georgia
Medical School: Mercer University School of Medicine-Savannah

CLINICAL YEAR 2

Chad E. Campion, MD
Undergraduate: Stevens Institute of Technology
Medical School: Rutgers New Jersey Medical School

Ryan B. Eads, MD
Undergraduate: University of Kentucky
Medical School: University of Kentucky College of Medicine

Matthew N. Fournier, MD
Undergraduate: University of Wyoming
Medical School: University of Washington School of Medicine

Peter R. Henning, MD
Undergraduate: Marquette University
Medical School: Medical College of Wisconsin

Andrew M. Holt, MD
Undergraduate: University of Tennessee
Medical School: Baylor College of Medicine

Catherine R. Olinger, MD
Undergraduate: Creighton University
Medical School: Creighton University School of Medicine

Zachary K. Pharr, MD
Undergraduate: Lipscomb University
Medical School: University of Tennessee Health Science Center College of Medicine

Carson M. Rider, MD
Undergraduate: Union University
Medical School: University of Tennessee Health Science Center College of Medicine

Current Orthopaedic Residents

CLINICAL YEAR 3

Austin R. Davidson, MD
Undergraduate: Lipscomb University
Medical School: University of Tennessee Health Science Center College of Medicine

Steven M. DelBello, MD
Undergraduate: Rhodes College
Medical School: University of Texas Medical Center, Houston

Donald B. Franklin, MD
Undergraduate: Samford University
Medical School: University of Tennessee Health Science Center College of Medicine

Clay G. Nelson, MD
Undergraduate: University of North Carolina
Medical School: Eastern Virginia Medical School

Mims G. Oschsner, MD
Undergraduate: University of Georgia
Medical School: Mercer University School of Medicine

Colin W. Swigler, MD
Undergraduate: Florida State University
Medical School: Florida State College of Medicine

Kirk M. Thompson, MD
Undergraduate: Rose-Hulman Institute of Technology
Medical School: Southern Illinois University School of Medicine

Jordan D. Walters, MD
Undergraduate: Furman University
Medical School: Wake Forest School of Medicine

CLINICAL YEAR 4

Thomas R. Acott, MD
Undergraduate: University of Illinois at Urbana-Champaign
Medical School: St. Louis University School of Medicine

D. Christopher Carver, MD
Undergraduate: East Tennessee State University
Medical School: East Tennessee State University James H. Quillen College of Medicine

Justin D. Hallock, MD
Undergraduate: Birmingham Southern College
Medical School: University of Tennessee Health Science Center College of Medicine

Travis W. Littleton, MD
Undergraduate: Lipscomb University
Medical School: University of Tennessee Health Science Center College of Medicine

Timothy M. Lonergan, MD
Undergraduate: Saint Louis University
Medical School: Saint Louis University School of Medicine

Erin M. Meehan, MD
Undergraduate: Clemson University
Medical School: Mercer University School of Medicine

A. Ryves Moore, MD
Undergraduate: University of Mississippi
Medical School: University of Mississippi School of Medicine

Daniel B. Wells, MD
Undergraduate: University of Georgia
Medical School: Mercer University School of Medicine

ATTRACTING WOMEN TO ORTHOPAEDICS

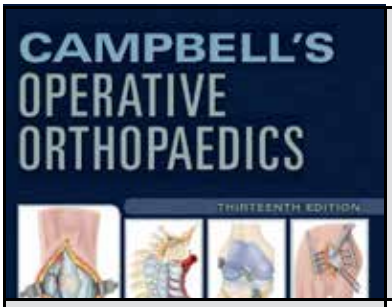
This summer, Kappa Delta Research Interns joined Dr. Karen Hasty and other researchers at University of TN- Campbell Clinic to conduct basic science orthopaedic research. At the end of their five week stay, this impressive group presented their research results at VA Medical Center. This program seeks to attract "best in class" women researchers to orthopaedics.

Projects presented:

- Protein Expression in GAGA4-silenced Osteoblasts
- Interactions between MHC class II molecules and T-cells in the Context of Rheumatoid Arthritis
- Generation of Citrullinated Type II Collagen for Use in the Collagen-Induced Arthritis Mouse Model Osteoarthritis-Targeted Delivery

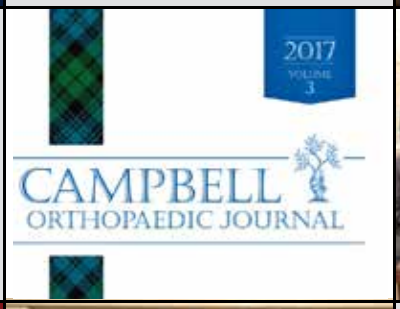
(From left) **Wendi Wang**, Albion College, MI; **Emily Peters**, Clemson University, SC; **Dr. Karen Hasty**, Wilhelm Professor of Orthopaedic Surgery; **Samantha Arroyo**, Florida Southern College, FL; and **Laura Dirienzo**, University of Rochester, NY.

Thank you, Campbell Alumni

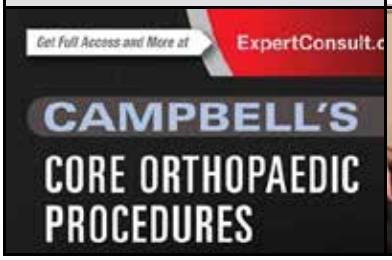


Community Health Care Outreach

Award Winning Research



40 Residents Trained



Thank you for your continued support.

The Campbell Foundation wishes to thank the Alumni who supported our mission in 2016.

Thank you for making an impact!

Andrew H. Crenshaw Jr. MD
Editor-in-Chief

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Campbell Clinic Orthopaedics is my team's **MVP.**

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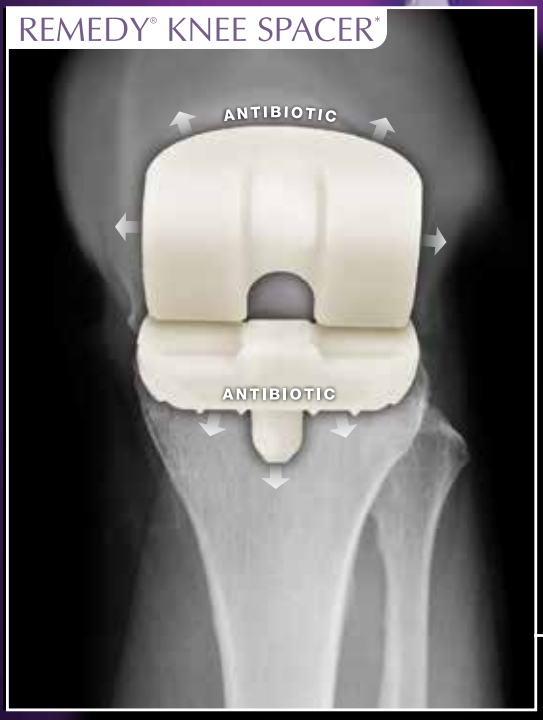

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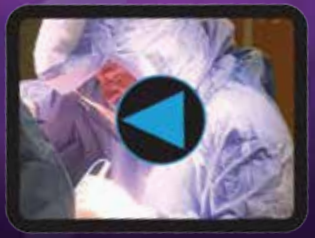

See the surgical technique video by ***Dr. Michael Meneghini*** *MD, Indiana University Health at our website*

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